Sky and TELESCOPE

The dome of the 200-inch telescope.

Vol. 1, No. 11
SEPTEMBER, 1942

Autumn Skies

The Starry Heavens in September

In Focus

OPHIUCHUS, from the average amateur's viewpoint, is one of the least known constellations in the sky. Its stars are mixed with those of Serpens—together these groups make a formidable collection of not-so-bright stars which are difficult to identify. However, it is in this part of the sky that many of the best features of the Milky Way are found.

The back-cover illustration this month shows the region around the star, Theta Ophiuchi, but it includes parts of Scorpius, Ophiuchus, and Sagittarius. September, early in the evening, is the best time to view these great clouds of stars and to make a comparison of the picture with the sky.

This region of the Milky Way is badly "messed up" by the numerous bright and dark nebulae. The lanes of obscuring nebulosity are the outlying tentacles of the large dark nebula near Rho Ophiuchi, which star would be about seven degrees west (to the right) of the right-hand side of the picture. The faint stars are exceedingly rich; in some places they are so close they give the appearance of nebulosity. It is doubtful that we see through this part of our galaxy even as far as 15,000 light-years, which is only half the distance to the galactic center.

The galactic center appears on this plate. Draw a diagonal line from a point on the left-hand margin four inches from the top to a point on the bottom edge four inches from the left, and you have roughly traced the equator of the Milky Way. The position of the center of the galaxy is on this line about two inches from the left edge, in a region singularly devoid of stars, clusters, and nebulae. (The galactic center is at R.A. $17^h\ 30^m$, Dec. $-30°$.)

The region of the galactic center, part of which is covered by this plate, is peculiar in many respects. It is the part of the sky in which the globular clusters congregate, indicating that it is also the center of their "system"; it is devoid of galaxies, from which we infer that we cannot see clear through our own galaxy in this direction; it is the region in which new stars, especially distant, faint ones, most frequently appear; it contains some Cepheid variables of high luminosity, which may possibly be observed even as far as the galactic nucleus itself, in spite of the obscuring haze.

The scale of the picture is roughly one inch to $1\frac{1}{2}$ degrees (one centimeter = 36′). Note Messier 6, located two inches from the left edge and $8\frac{3}{4}$ inches from the top; also, the famous "S" dark nebula, $4\frac{1}{4}$ inches from the left edge and $3\frac{1}{4}$ inches from the top. X Sagittarii, a Cepheid variable, is just about the most "central" naked-eye star, as it is only three degrees from the galactic center to the northeast—its position, following the designations above, is $\frac{7}{8}$ x 6.

Also find Theta Ophiuchi, $4\frac{1}{2}$ x 4; X1 Ophiuchi, $4\frac{5}{8}$ x $1\frac{5}{8}$; 45 Ophiuchi, 3 x 7; M19, $7\frac{1}{4}$ x 5; M62, $7\frac{3}{8}$ x $7\frac{3}{8}$. A slight extension of the picture below its left part would show the stars in the Scorpion's tail, while M8 and M20 (cover of June, 1942) are off the upper left edge.

Sky and Telescope

Copyright, 1942, by
Sky Publishing Corporation

CHARLES A. FEDERER, JR., *Editor* HELEN SPENCE FEDERER, *Managing Editor*

EDITORIAL ADVISORY BOARD: **Clement S. Brainin,** Amateur Astronomers Association, New York; **Edward A. Halbach,** Milwaukee Astronomical Society; **Donald H. Menzel,** Harvard College Observatory; **Paul W. Merrill,** Mt. Wilson Observatory; **Oscar E. Monnig,** Texas Observers; **Henry Norris Russell,** Princeton University Observatory; **Charles H. Smiley,** Ladd Observatory; **Percy W. Witherell,** Bond Astronomical Club.

The Editors Note . . .

A CONTINUOUS flow of inquiries is received as to progress being made on the 200-inch telescope, although numerous publications have carried information on its construction. Perhaps our correspondents are concerned over the future of this Goliath of telescopes, symbol of scientific progress in America.

In response to our request for information, Dr. J. A. Anderson, executive officer of the Observatory Council of California Institute of Technology, has written in part:

"Last year, even before Pearl Harbor, it became necessary for our personnel to turn their attention to defense work, and by the middle of the year all work on the telescope of a mechanical nature had to be stopped for the duration of the emergency Optical work continued until the end of the year, when that also had to be stopped. The grounds at Palomar Mountain were closed to the public and only two or three maintenance workers remain there.

"In the optical shop we keep the 200-inch mirror...but the last interval on the grinding of the mirror was in April, so we may as well say that no work is now being done on the optical parts.

"...A full year's work will be required to finish the job, when the war is over."

A good source of information about the 200-inch telescope is the department "Telescoptics," in recent issues of *Scientific American;* also the book, *The Glass Giant of Palomar,* by David O. Woodbury. In our own forbear, *The Telescope,* March-April, 1940 (copies still available), Dr. Anderson and Russell W. Porter wrote a comprehensive discussion of the then 11-year venture. This is illustrated with many of Mr. Porter's famous drawings.

From the esthetic angle, the building housing the 200-inch instrument leaves little to be desired, especially in the setting which greets the traveler on his way up the mountain. Our front cover this month is one of the vistas along the highway, and shows the character of the roadway by which the observatory is reached.

VOL. I, No. 11

CONTENTS

SEPTEMER, 1942

COVER: A turn in the road up Palomar Mountain in the Cleveland National Forest reveals the dome of the 200-inch telescope. Photo by Josef Muensch, Santa Barbara, Cal.

SIRIUS and Its Companion—Robert G. Aitken 3
ELEMENTS OF CELESTIAL NAVIGATION—Fletcher G. Watson 7
AUTUMN SKIES—William H. Barton, Jr. 12
CONFERENCE ON SPECTROSCOPY 16
HOW ELLIPTICAL IS MY ORBIT? 17

Amateur Astronomers 15
Astronomical Anecdotes 10
Beginner's Page 11
Books and the Sky 19
Do You Know? 17
Gleanings for A.T.M.s 18
Here and There with Amateurs 23
News Notes 6
Observer's Page 20
Planetarium Notes 23

The Starry Heavens in September 22

BACK COVER: A rich region of the Milky Way; see "In Focus" for details. Photo by Frank E. Ross, at Flagstaff, Ariz., May 24, 1931, exposure $3^h\ 20^m$ with a 5-inch f/7 Ross lens. The coordinates of Theta Ophiuchi are R.A. $17^h\ 19^m$, Dec. 24° 57′. From Plate 3 of the *Atlas of the Northern Milky Way,* by Frank E. Ross and Mary R. Calvert.

SKY AND TELESCOPE is published monthly by Sky Publishing Corporation. Entered as second class matter, April 28, 1939, at the Post Office, New Rochelle, N. Y., under Act of March 3, 1879. Publication office: Manchester, N. H.; re-entered as second class matter at the Post Office, Manchester, N. H.
Subscription: $2.00 per year in the United States and possessions; $2.50 foreign (including Canada). Single copies: 20 cents. Make checks and money orders payable to Sky Publishing Corporation. Send notice of change of address 10 days in advance.
Editorial and general offices: Harvard College Observatory, Cambridge, Mass.

SIRIUS

and Its Companion

By Robert G. Aitken

Director Emeritus, Lick Observatory

IT is a pleasure to accept the invitation from the editors of *Sky and Telescope* to contribute a paper on Sirius for the series on well-known stars, even though there is little that is new which can be said of it now, for Sirius has been of exceptional interest to me ever since 1896, when I had the quite unexpected opportunity to write a short paragraph of its history.

It may be well to begin with that anecdote, for many of my readers may not know how it came to pass that a man quite unknown in the astronomical world should be the first to see a star for which many astronomers were searching.

In the years 1891-95, I was teaching mathematics and astronomy at the University (now the College) of the Pacific, and had the privilege of taking my astronomy class to the Lick Observatory on special nights once or twice a year. I became well acquainted with Dr. Edward S. Holden, and, indeed, spent the first two weeks in June, 1895, as his house guest on Mt. Hamilton, using some of the smaller instruments and getting an insight into the methods of work at a great observatory. I was giving all my spare time to the study of astronomy, in which my college training, under Prof. Truman H. Safford, at Williams College, had been sound but elementary, and hoped that the way might open some day to a career in astronomy.

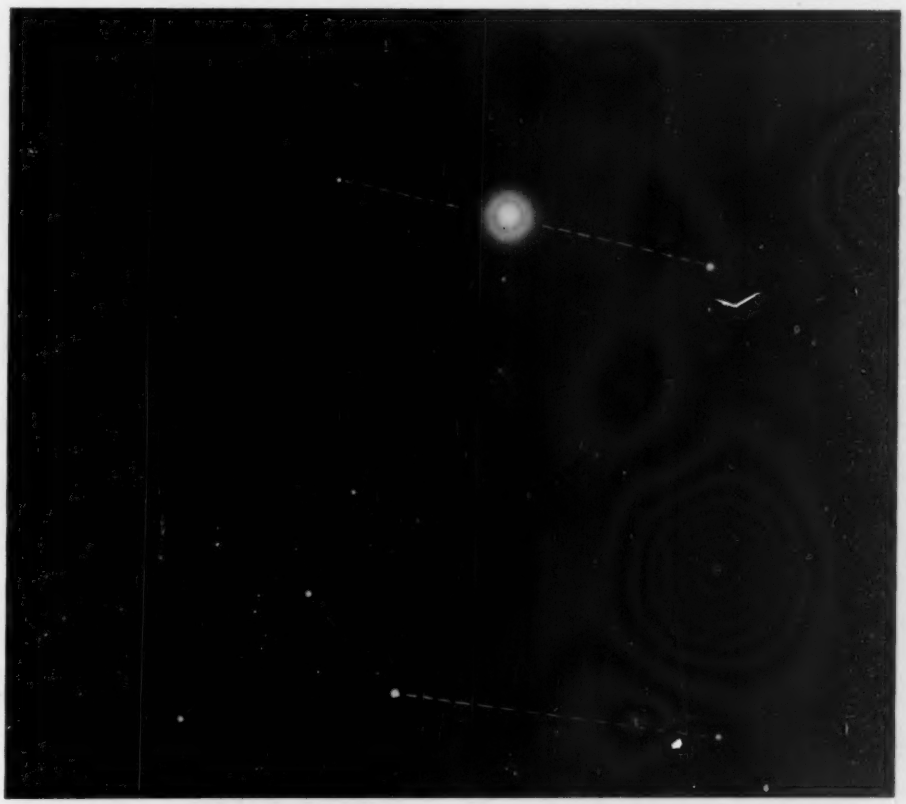
In December, 1895, Dr. Holden sent a telegram asking me to take dinner with him at the Vendome Hotel in San Jose, and in the course of the after-dinner conversation, said that if he succeeded in certain arrangements he was planning to make, he could offer me a position as assistant astronomer for the year beginning July 1, 1896. The position would be for one year only, with no assurance of renewal, but I accepted promptly, trusting in Providence for the future.

In May, 1896, however, Dr. Holden had to tell me that his plans had gone awry and he would have no position for me. We did, however, arrange that I should spend the long summer vacation on the mountain with Mrs. Aitken and the children, "camping out," as he expressed it, in a little cottage which Prof. E. E. Barnard had just vacated to move into the new house built for him. Then, before we had been on the mountain a week, he offered me a special position for one year only, from July 1, 1896, at half the pay of an assistant astronomer, but *carrying that title*. With characteristic consideration, he bade me to make no reply until I had discussed the matter with Mrs. Aitken, for, said he, "The hardship of life on the mountain, with small children and no household help, will fall on her." Mrs. Aitken was "game," as she has ever been, and I accepted, determined to make the most out of my year. That my trust was not misplaced is evident from the fact that we remained on the mountain for 40 years!

My duties in my temporary position were to be participation in the routine work of the observatory, and the reduction of some meridian-circle observations to which Dr. Holden had pledged himself. I was to spend three hours a day on the latter job, from 9 to 12 a.m.—and 9 with Dr. Holden meant 9 a.m. precisely. Aside from that, my time was my own, and I could use any of the instruments freely, except the meridian circle, which was reserved for Prof. R. H. Tucker's exclusive use, and the 36-inch. I could use the latter, too, at any time I found it standing idle, with the micrometer attached. Since the regular observer, in those days, worked from dark to daylight, this frequently happened at the beginning or end of the long winter nights, and I lost no opportunities.

Early in the summer I had determined to take up some form of double-star work, influenced not only by my own predilections, but also by Prof. Barnard's strong arguments. He pointed out that I had the best location and telescopes in the world for that kind of work and the opportunity to formulate my own program, since no one else was then engaged in work of that kind at the observatory. Meanwhile, I was using the micrometer to observe comets, satellites, and double stars and, in particular, was measuring double stars for Prof. S. W. Burnham, to whom Barnard had introduced me by letter, to help him make his *General Catalogue* more complete.

On October 23, 1896, therefore, after a heavy day's work, I went up to the 12-inch telescope, planning to work only till midnight that I might come to my desk fresh for the next morning's computing work, but I found the seeing so extraordinarily good that I continued work until toward morning. Then before going home I went across to the 36-inch dome to see how Prof. J. M. Schaeberle was getting on. I was surprised to find that he had gone home, leaving the telescope safe for the night. The dome was open, and Sirius, near the meridian, was shining directly in through the slit. It was the work of a few minutes to put the telescope into commission and turn



The stars in Canis Major form principally a straight line, with Sirius in the middle, and a triangle. Note the clusters M41, below Sirius, and M46, in upper left. Photograph taken with 120-minute exposure of 1½-inch Cooke lens, at Harvard's Station at Bloemfontein, South Africa, March 1-2, 1940.

it on the star. There stood the tiny companion as sharply and clearly defined as I have ever seen it, and both star images were perfectly steady. Without waiting to get my notebook, I recorded a complete set of measures on the back of an envelope, determined my constants, and then turned up the telescope and went home happy in the thought that I, too, had seen the tiny companion on the first night of its emergence from the rays of its bright primary. I assumed, of course, that Prof. Schaeberle had made measures of it before leaving the dome.

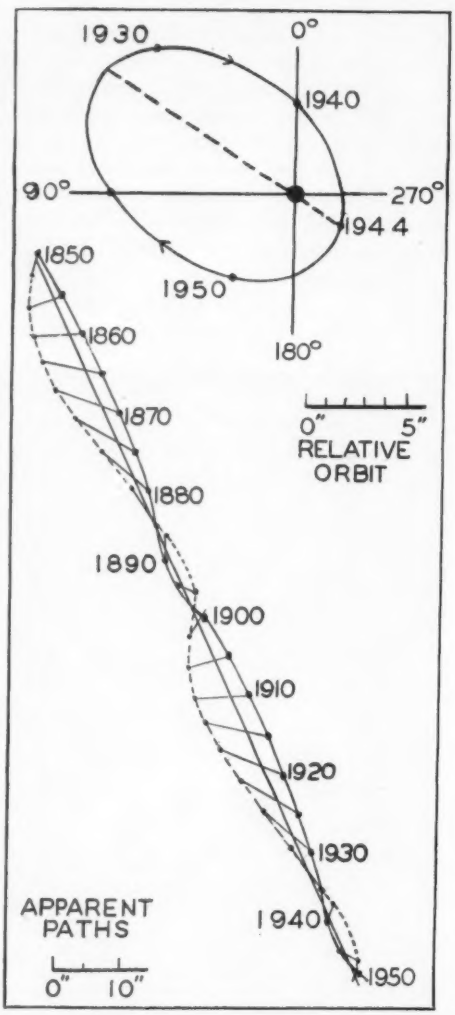
Next morning, however, when I went to him to compare notes, I found that he had been seized with a violent headache the night before, and had, moreover, the misfortune of breaking a micrometer thread at the very beginning of his night's work. As was our custom then, he had taken the micrometer to his office and set in a new spider thread, a delicate operation under the best of conditions. This did not help his headache, and by midnight he had been obliged to give up work. My observation of the companion of Sirius was, therefore, the first to be made since Burnham lost it in the rays of Sirius itself in 1892. Dr. Holden would not, of course, communicate the measure to other astronomers until it had been verified by a more experienced observer, since I was quite unknown to the astronomical world. Happily, Prof. Schaeberle was able to do this on the following night.

But why all this excitement about the observation of a double star? The answer lies in the history of the star to which we now turn.

Since it is the brightest star in the firmament as viewed from the earth, Sirius must have attracted the attention of the very earliest stargazers. It was the center of a veritable maze of myth and legend; temples were erected in its honor and, what is of more consequence astronomically, an accurate record of the time of its heliacal rising was kept from about 300 B.C. Those who are interested in early star lore will find full references to the literature on Sirius in Lockyer's *Dawn of Astronomy*, and Allen's *Star Names and Their Meanings*.

Here we are concerned purely with its astronomical history, and the first point to notice is whether the star has changed color since classical times. This is a question which has been hotly debated. There are many references in classical literature to Sirius as a red star, but in recent years there is no question but that it has been a white star. Father Angelus Secchi took it, indeed, as his type white star in his classification of stellar spectra in 1863, and there has been no change in the character of its spectrum since. T. J. J. See, about 50 years ago, marshaled the evidence in favor of a change in color and G. Schiaparelli presented evidence to the contrary. Astronomers generally sided with Schiaparelli's views, and attributed the apparent red color noted by the ancients to the strong scintillations of the brilliant star shining through the disturbed atmosphere over ocean and desert.

But if the star has not changed in color, it has changed its position in the sky with respect to other stars, as Edmond Halley discovered in 1718. Curiously, little emphasis is given to this discovery in modern textbooks on astronomy. They usually simply state that Halley was the first to note that Arcturus, Sirius, and a few other stars had changed their positions in the sky relatively to the other stars, and then pass on to a general discussion of proper motions without calling attention to the change wrought by this discovery in man's concept of the universe—a change but little short of that brought about by the work of Copernicus and Galileo.



The apparent relative orbit of Sirius' companion (after Baker), and the apparent paths of the two stars across the sky (after Russell, Dugan and Stewart). The wavy motion of Sirius indicated to Bessel the presence of the companion. The mass ratio of five to two is found from the relative deviation of the two stars from the straight line path of the center of gravity.

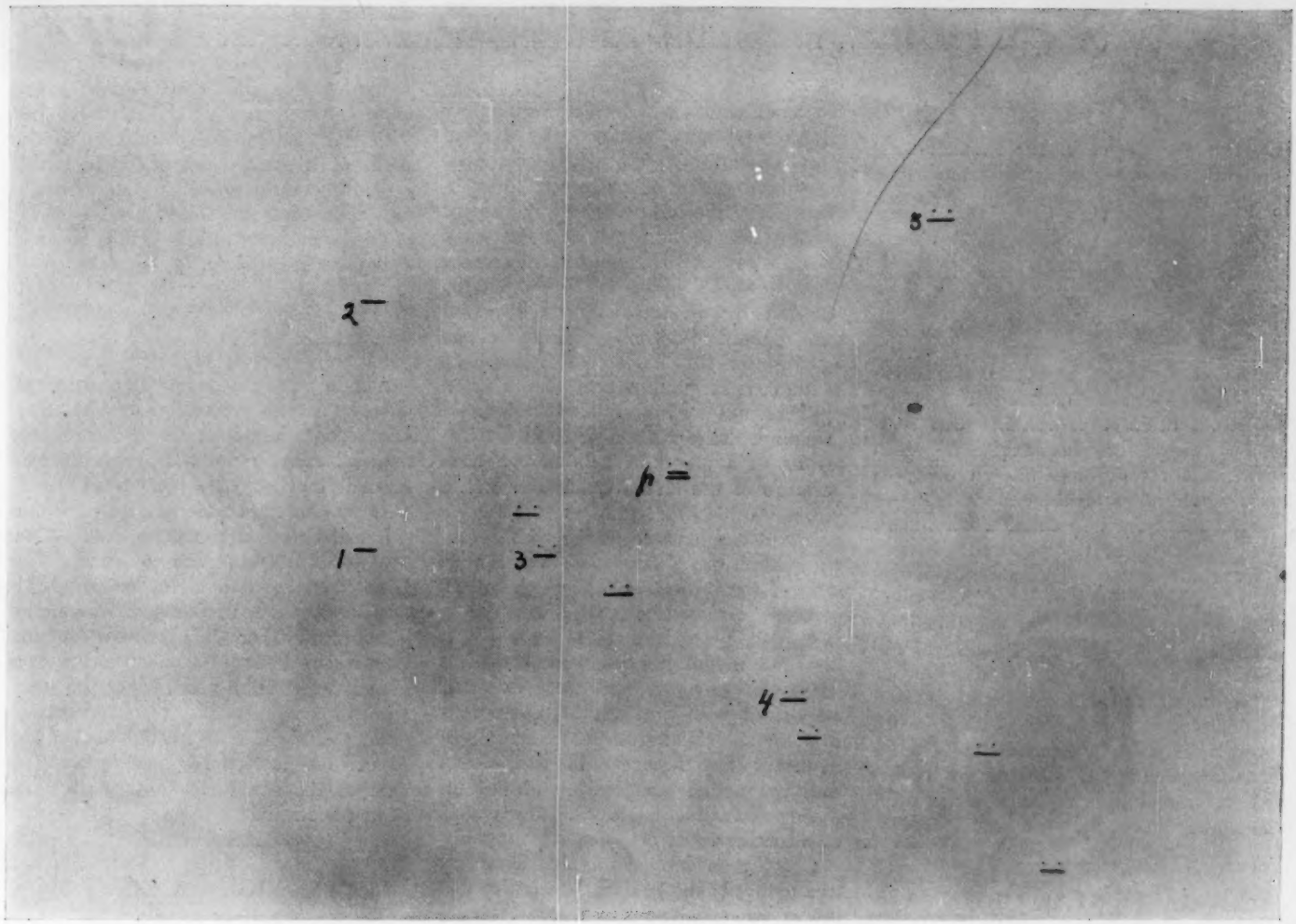
Prior to Halley's discovery, the sun and all of the stars were regarded as fixed bodies in space, every one holding the position assigned to it at the Creation. After Halley, that view was impossible; for, if a few stars were in motion, all might be, and man's entire outlook upon the nature and origin of the universe had to undergo radical revision.

This is not the place to pursue this subject, but we might pass on to the fact that while Halley detected the proper motion of Sirius, he did not note that its motion was not at a uniform rate, but described a wavy line. This discovery was reserved for Bessel, who, about 100 years ago, showed that Sirius moved as though it had a dark companion, massive enough to swing the bright star with it in an elliptic orbit about a common center of gravity in a period of 50 years. It was in his paper on this subject, I think (though I am at present not in position to consult the original), that Bessel made his famous statement that luminosity is not an essential attribute of a star. There might be many dark stars—dead bodies, so to speak—that would exercise gravitational attraction upon others.

Then in 1862, Alvan G. Clark discovered a tiny companion to Sirius, while testing the 18½-inch telescope now at the Dearborn Observatory. The question immediately arose as to its identity with Bessel's hypothetical dark star. Computations made by several astronomers, including Prof. Safford, my former instructor at Williams College, showed the possibility of such identity.

The tiny companion was followed by double-star observers as it gradually approached its primary, and the last measure before its disappearance was secured by Burnham with the Lick 36-inch telescope in 1892. Then it was lost in the rays of the bright star. The arc observed in the years 1862-1892 was not long enough to permit the computation of a good orbit. It was necessary to *assume* the identity of Clark's companion with the one predicted by Bessel, and the consequent revolution period of 50 years. The question to be decided was whether this assumption was correct, which could be answered if, when the companion again became visible, it appeared in the position predicted upon that assumption. The measures secured by Prof. Schaeberle and myself settled that point, for we found the star close to its predicted position.

But now new questions arose. By the end of the century, the distance of Sirius (8.8 light-years) as well as its radial velocity and proper motion, had been well determined. Now a thoroughly reliable orbit could be computed for the system, and from the proper combination of the data, the mass of the system and of each component separately could



The distance of Sirius is determined from parallax plates such as this one taken at Van Vleck Observatory. To make possible measurement of its position with those of the numbered faint stars, the Dog Star's light is reduced by 10.5 magnitudes (about 16,000 times) by a rotating sector. Two 5-minute exposures are shown; the images of Sirius are doubly underlined.

be derived. The masses were found to be 2.44 and 0.88 times the sun's mass, for Sirius and its companion, respectively.

The spectrum of the faint star was somewhat more uncertain because of the presence of the brilliant white primary, but it was possible to say that the companion was of spectral type earlier than *F*0 (now known to be A5) while Sirius itself is of type A0. Thus, they are both stars of comparatively high surface temperatures, and therefore of nearly the same radiation per unit area of their surfaces. But Sirius is of apparent magnitude −1.6, and its companion is 8.4, so the former radiates 10,000 times more light than its companion, which must consequently be a very small star.

It is impossible to measure the diameters of the two stars directly, but by this and other indirect methods that have given fairly reliable results, it is safe to conclude that their ratio is about 50 to one. It follows, since Sirius has been found to be in all respects an ordinary star, owing its brilliancy chiefly to the fact that it is so near to us, that its companion must be extraordinarily dense. It became the first known *white dwarf*, of which other examples are being found constantly.

The questions are: how can we have matter so exceedingly dense which retains the properties of a gas; and in the second place, how can we explain the co-existence of such a body in conjunction with a normal star? Eddington suggested a relief from the first difficulty by his theory that the atoms in such dense stars as white dwarfs have become completely ionized—the outer electrons and the nuclei can then be packed far more closely together, and the body attain the extraordinary density of 50,000 times that of water and still retain its gaseous properties.

A little later came Einstein with his theory of general relativity, one consequence of which is that light in passing through or emanating from a strong gravitational field will be, as it were, slowed up—that is, the spectral lines will be shifted toward the red end of the spectrum. In a single star this shift cannot be separated from the radial velocity shift due to motion away from us, but in a double star like Sirius, this latter shift can be accurately calculated from the constants of the orbit. The spectral lines of the faint companion of Sirius are very difficult to measure because of the blending with the lines from the bright star, but Walter S. Adams accomplished this with the 100-inch telescope at Mt. Wilson, and his result was verified a little later by J. H. Moore at the Lick 36-inch. Einstein's predicted shift amounted to 17 kilometers per second; Adams observationally found 19 kilometers per second, and Moore's result was but little greater.

These observations are strong evidence supporting the extraordinary density of the star and the correctness of Einstein's theory. There are still doubters who hope that some other explanation for this density may be found and, in any event, the association of these two stars into a single double-star system has found no explanation.

The companion of Sirius is now in about the position it held when Burnham observed it in 1892. I hope to live long enough to learn, after its emergence in about 1946, following periastron passage, whether or not it will again be found in its predicted place.

NEWS NOTES

By Dorrit Hoffleit

CAN YOU PRONOUNCE?

How the names of the constellations should be pronounced is not always perfectly obvious to those of us who are not philologists. James Stokley, of Science Service, effectively describes a few of the popular variations on some of the most commonly mispronounced terms. Take for example the name of Alpha Orionis, Betelgeuse, which is sometimes called *Bet*-el-gerz, sometimes Beh-*tell*-gyou-eez, and even "beetle-juice."

In an attempt to remedy this non-homogeneity of pronunciation—which often renders familiar written concepts orally unintelligible—the American Astronomical Society appointed a committee to prepare a list of preferred spellings and pronunciations. The committee consisted of Dr. S. G. Barton, of the Flower Observatory, chairman; Daniel J. McHugh, C.M., De Paul University; and George A. Davis, Jr., of the Buffalo Museum of Science. Their list of pronunciations is published in the August issue of *Popular Astronomy*. It is heartily recommended to everyone, especially for reference use by popular lecturers and other teachers of the uninitiated.

VARIABLE STAR OBSERVATIONS FROM INDIA

The recorder of the American Association of Variable Star Observers, Leon Campbell, reports that observations of variable stars have continued to flow in from India, despite the difficulties and delays in transportation, and despite the great menace of war. He has received large numbers of estimates of the brightnesses of variable stars from R. G. Chandra, of Bagchar, about every six months; and M. K. Bappu, at the Nizamiah Observatory at Begumpet, has also sent in observations that are particularly valuable because many of them were made when the stars concerned were at their faint phases. Although we cannot expect to continue to get such reports regularly, Mr. Campbell expresses hopeful confidence that faithful observing will continue, and that the results will eventually get into the hands of the A.A.V.S.O.

SHOCK WAVES AND METEORS

Occasionally war problems may suggest problems in astronomical research. Thus Capt. Theodore E. Sterne, of the Ballistics Research Laboratory at Aberdeen Proving Ground, has not altogether confined his thoughts and investigations on projectiles to bullets or bombs. In "A Remark on Meteors" in a recent number of the *Astrophysical Journal*, he discusses the shock waves which must accompany all meteors, since meteor velocities are much greater than the speed of sound.

In the direction of the meteor's motion the shock wave has a velocity in general equal to that of the projectile. The wave does not necessarily touch the meteoroid itself; for the latter is probably surrounded by an envelope of liberated gas. Behind the meteoroid, the shock wave presumably has a conical shape, as in the case of gunfire shock waves when the velocities are higher than the velocity of sound. The passage of such a wave results in a great increase in the temperature of the air affected. Dr. Sterne gives formulae for estimating the pressure and temperature of the compressed air behind the shock wave but just in front of the projectile. The highest temperature reached just in front of a meteor, he finds, is of the order of a million and a half degrees absolute. This is an upper limit and in substantial agreement with previous determinations by others. The figure is so enormous, however, that there can be little doubt that the actual temperature of the air during and immediately after the passage of a meteor must be extremely high.

Dr. Sterne has given a preliminary treatment of the problem. He hopes that others will analyze the physical consequences more extensively than he has done, since circumstances prevent his continuing the investigation himself at present.

NOVA HERCULIS' RING NEBULA

Nova Herculis, glamour star of 1934, repeatedly finds means to return to the limelight. Now, according to Dr. Walter Baade, of the Mt. Wilson Observatory, the shell surrounding the already faint star is developing most interesting spectral features. The thickness of the expanding shell (a ring nebula), believed to have been expelled from the star when it "exploded," is considerable, amounting to over half its extreme radius.

In ordinary blue photographic light, the so-called forbidden emission lines of doubly ionized oxygen observed in its spectrum indicate that the shell is elliptical and of nearly uniform intensity all the way around. In the red part of the spectrum, however, strong forbidden lines of ionized nitrogen show that the atoms responsible for these lines are restricted to two pairs of condensations symmetrically located with respect to the center of the nebula. The stronger pair of condensations has a separation of 1″.8 on the minor axis; the lesser, of 3″.2 on the major axis, the extreme diameters of the shell being 2″.95 and 3″.67, respectively.

The spectral lines observed are called forbidden because they cannot occur under ordinary terrestrial conditions. But with the vacuum-like conditions in the shells of planetary nebulae, which this expanding shell resembles, terrestrially forbidden lines are common. See "Ages of Observation," by L. H. Aller, *Sky and Telescope* last month.

MT. WILSON ANNUAL REPORT

Annual reports from practically all observatories nowadays begin with statements on the depletion of staff for national defense activities, with the consequent curbing of astronomical activities. This is likewise true of Dr. Walter Adams' report on the work done at the Mt. Wilson Observatory during the 1940-1941 period. Nevertheless, his nearly 30-page account of researches accomplished or in progress is impressive. About 80 notes and longer papers were published during the year, covering a wide variety of observational, theoretical, and instrumental topics, and concerning celestial objects from as near as the sun to as far as space has been penetrated.

COPERNICUS SOCIETY IN NEW YORK

In 1543 Copernicus published his *De Revolutionibus*. In commemoration of this 400th anniversary, the Copernican Society has been formed, with headquarters at 459 East 133rd St., New York City. The society plans to publish the first English translation of *De Revolutionibus*, and Dr. Edward Rosen, of the College of the City of New York, authority on Copernican treatises, has been chosen as translator. An article by Dr. Rosen concerning the original publication of the Copernican theory appeared in The SKY, September, 1940.

MOON ILLUSION

How big does the moon look to you? Are you surprised because it looks much larger near the horizon than when it is high in the sky? If so, you may have noticed that the illusion of super-size disappears when you view the horizon moon with your head upside down, for instance, when you look at the moon between your legs!

Prof. E. G. Boring and his associates at the Harvard Psychological Laboratory have undertaken precise measurements to determine just how large the moon appears, both on the horizon and near the zenith. They have had various observers compare the moon with an arti-

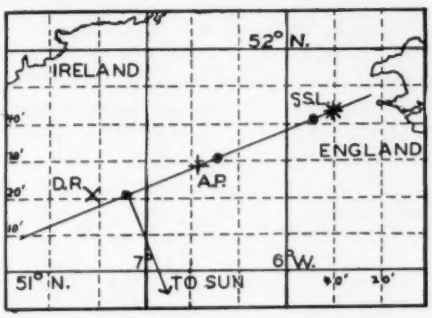
(Continued on page 17)

Elements of Celestial Navigation

By Fletcher G. Watson
Harvard College Observatory

The basic instruments in navigation are chronometer, compass, and sextant. For star sights, the sextant is used during twilight and dawn, when the bright stars and the horizon are both visible. United States Navy photo.

In the early days of celestial navigation, the significance of the now well-known line of position was not recognized. Observations of the sun to determine latitude were made at noon, and to determine longitude, early in the morning and late in the afternoon when the sun was nearly east and west, when errors in the latitude of the ship had little influence. The possibilities of using observations at any time of day were not realized until Capt. Thomas H. Sumner, a Yankee master out of Salem,



The first Sumner line of position was drawn under the conditions shown here. D.R. is the dead reckoning position; A.P. is the actual position (as turned out later); S.L. is Smalls light. The three computed positions are all on a line running at right angles to the direction of the sun. Tuskar light is on the Irish coast, toward which the wind was blowing—hence the "danger."

Mass., found himself in a difficult position, which he reported as follows:

"Having sailed from Charleston, S. C., November 25th, 1837, bound for Greenock, a series of heavy gales from the westward promised a quick passage; after passing the Azores the wind prevailed from the southward, with thick weather; after passing longitude 21° W. no observation was had until near the land, but soundings were had not far, as was supposed, from the bank. The weather was now more boisterous and very thick, and the wind still southerly; arriving about midnight, December 17th within 40 miles, by dead reckoning, of Tuskar light, the wind hauled SE. true, making the Irish coast a lee shore; the ship was then kept close to the wind and several tacks made to preserve her position as nearly as possible until daylight, when, nothing being in sight, she was kept on ENE. under short sail with heavy gales. At about 10 a.m. an altitude of the sun was observed and the chronometer time noted; but, having run so far without observation, it was plain the latitude by dead reckoning was liable to error and could not be entirely relied upon.

"The longitude by chronometer was determined, using this uncertain latitude, and it was found to be 15′ E. of the position by dead reckoning; a second latitude was then assumed 10′ north of that by dead reckoning, and toward the danger, giving a position 27 miles ENE. of the former position; a third latitude was assumed 10′ farther north, and still toward the danger, giving a third position ENE. of the second 27 miles. Upon plotting these three positions on the chart, they were seen to be in a straight line, and this line passed through Smalls light.

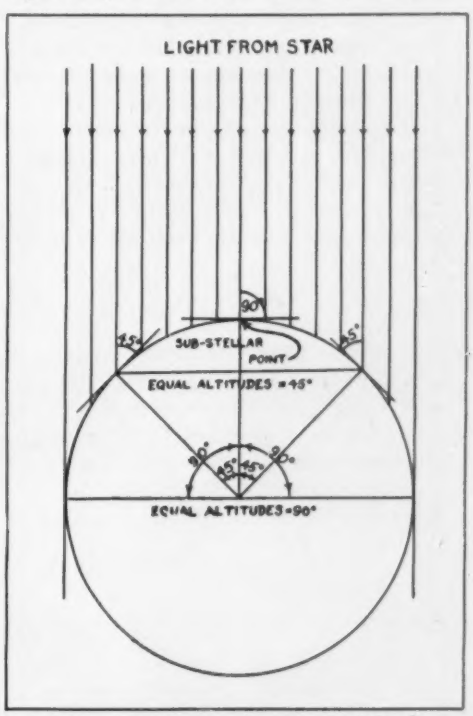
"It then at once appeared that the observed altitude must have happened at all of the three points and at Smalls light and at the ship at the same instant."

Bowditch's *American Practical Navigator,* from which this quotation is requoted, then goes on to say that "although the absolute position of the ship was uncertain, she must be somewhere on that line. The ship was kept on the course ENE., and in less than an hour Smalls light was made, bearing ENE. ½ E. and close aboard."

Upon returning to Salem, Capt. Sumner discussed the problem with Prof. B. Peirce of the mathematical department at Harvard. They could find nothing wrong with the procedure, so Sumner published a little book telling the world of his discovery. Now every navigator uses Sumner lines of position on all possible occasions. Sumner's method is the basis of modern celestial navigation, no matter how modified it may be by later improvements and short cuts.

Although there are many subdivisions, the general subject of navigation consists of two distinct parts: piloting and celestial navigation. The first includes locating and conducting the vessel in a harbor or coastal waters where lighthouses, buoys, and radio beacons serve as guideposts. The process is similar to touring by auto, where a good road map and signposts indicate the traveler's position and the route he should take to reach his destination.

When a ship is far at sea, only the celestial bodies can be used to indicate its location. This process is *celestial navigation,* sometimes called nautical astronomy or astro-navigation. The geometry of the solution is simple, but as



When the altitude of a star is 90°, the observer is at the substellar point; when the altitude is 45°, the zenith distance of the star is also 45°, and that is the radius of the circle of position. When the star is on the horizon, the observer is 90° away from the substellar point.

Capt. Sumner's experience indicates, several hundred years have been required for the development of the instruments and methods necessary in practice.

All the navigator can establish from observations of a single celestial body at one time is the *line of position*—a line on which the vessel must be located. The position of the vessel is fixed by crossing two such lines at a goodly angle (giving a *fix*), this requiring a second celestial body. In the daytime this may be the moon or a bright planet, assuming the sun to be the first body observed. After sunset and before sunrise, the moon, planets, and bright stars may be used.

A line of position is established when the navigator knows how far he is from some reference point—such a line is actually a circle around the point. The exact location of the vessel along this line could be found from a single observation if it were possible to observe the direction of the reference point as accurately as its distance. Unfortunately, the navigator must refer such observations of direction or *bearing* to his compass, and even the modern gyrocompasses are not of sufficient accuracy to give the position within a few miles. The problem, then, is to fix the reference point and to measure accurately the distance of the vessel from it.

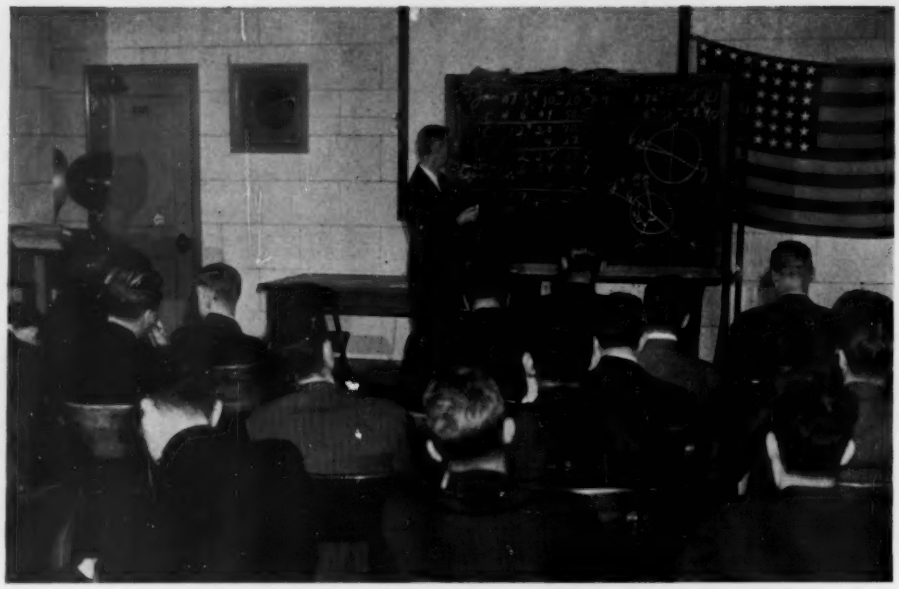
For observations of some celestial body, let us say the sun, the most natural reference point is the place on the earth which has the sun directly overhead—in the zenith. At any instant there is always some place on the earth from which the sun is seen in the zenith; there are others which have overhead. respectively, the moon, each of the bright planets, and any star.

If astronomers can provide tables from which the *subsolar*, *sublunar*, and *substellar* points[1] can be found at any instant of time, then the navigator has his problem half solved. Such tables make up the *American Nautical Almanac*, published for a whole year in advance and selling for only 50 cents. The observations and theory underlying the production of this compact book date back at least as far as the founding of the Greenwich Observatory in 1675. This first national observatory was established specifically to provide British sailors with navigational information on the positions of the heavenly bodies. Before the advent of astrophysics, much of conventional astronomy dealt with the intricacies of this same problem.

From his almanac the navigator can find the subsolar point at any instant. But as the earth rotates, the subsolar point sweeps over its surface. In equatorial regions its speed is about 1,000 miles an hour; in temperate latitudes it is on the order of 800 miles an hour. Thus, for the subsolar point to be located within a mile in longitude, the time of the observation must be known to a thousandth of an hour, or about four seconds of time. Before the advent of radio time signals, "every hour on the hour," navigators had to rely on the accuracy of the clocks or watches they carried.

According to Willis I. Milham's *Time and Timekeepers*, the governments of both England and France in about 1715 offered large prizes for devices or methods by which the longitude of a vessel at sea could be determined with an error less than two degrees—nearly 150 miles at the equator. Such uncertainties now seem appallingly large, but we need only to look at old maps to see how badly in error were the longitudes assigned to the coastlines of the American continents and the adjacent islands. The problem was finally solved in 1761 and the prize won by John Harrison, generally known as "Longitude" Harrison, who developed the chronometer. This is essentially a fine, sturdy watch made to run accurately for long intervals under the varying conditions at sea. From it the navigator can find the Greenwich time of his observations and thus *enter* the *Almanac* for the correct instant.

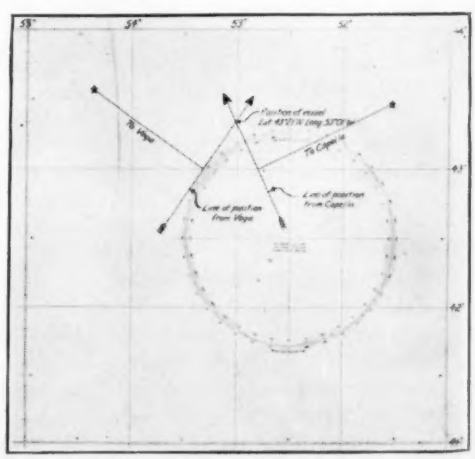
The *Almanac* tabulates the Greenwich hour angle (*GHA*) and the declination (*Dec*) of the various observable bodies, including 55 stars of the 1st and 2nd magnitudes. The *GHA* measures how



This is a class in navigation conducted by the United States Power Squadron as a "refresher" course for Navy and Coast Guard men. Note the time diagrams on the blackboard—these help in visualizing problems of time and longitude. Photo by Don Selchow; engraving, courtesy "The Ensign" and the U.S.P.S.

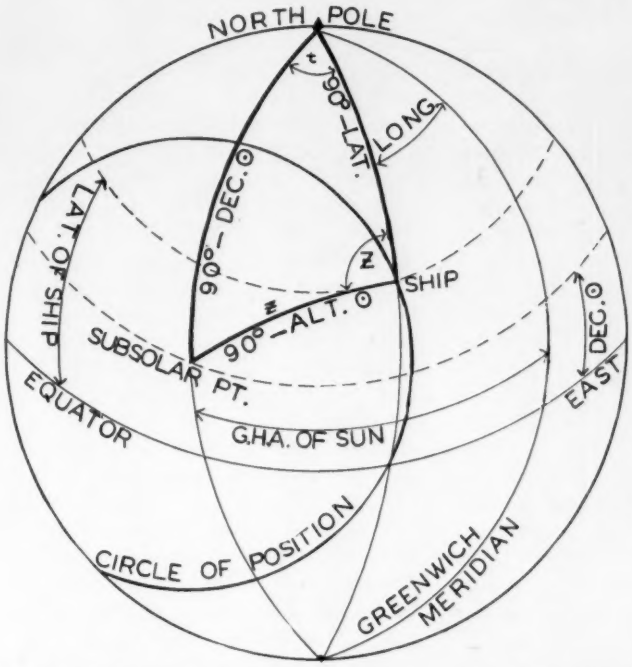
[1] For simplicity, we shall refer only to the subsolar point in our present discussion.

Left: Even on a small-scale chart, only relatively small portions of the circles of position can be drawn accurately and easily. In this case the position of the vessel is determined from observations of Vega and Capella.



Right: Simplification of the drawing of circles of position is achieved by approximating their arcs with straight lines perpendicular to the directions of the celestial objects. The position of the ship is determined as accurately as when arcs are drawn, within the errors of the sextant observations.

far the body (say, the sun) is westward from the meridian of Greenwich. But longitudes are also measured from Greenwich; thus, the *GHA* can be taken as the longitude of the subsolar point. The *Dec* is the angular distance the body (sun) is north or south of the celestial equator, and is therefore equal to the latitude of the subsolar point—north or south of the earth's equator. These two tabulated quantities, the *GHA* and the *Dec*, then, locate the subsolar, sublunar, subplanetary, and substellar points, as the case may be.



Here the astronomical triangle is brought down to earth. Its three corners are, respectively, the pole, the vessel, and the subsolar point. The angle t is the difference of longitude of the vessel and the subsolar point, and the angle Z is the azimuth of the sun, always expressed as less than 180 degrees. The sides of the triangle are the complements of the sun's declination, the vessel's latitude, and the sun's altitude.

If the vessel happens to be exactly at the subsolar point, the sun is in the zenith and its *zenith distance* is thus zero. If the vessel is a degree away from the subsolar point, the sun is a degree from the zenith; if 40 degrees away, the sun's zenith distance is 40 degrees. In this last instance, its *altitude*, or angular height above the horizon, would be 90 minus 40, or 50 degrees. It is the altitude which the navigator measures with his sextant, and subtracts from 90 degrees to get the zenith distance of the sun at the instant of his observation. The observed zenith distance then fixes the vessel's distance from the subsolar point, and locates the vessel somewhere on a *circle of position*.

If the navigator's charts were large enough, he could plot the subsolar point and draw around it a circle of position with a radius equal to the observed zenith distance. The ship must be located on that circle, otherwise that particular value of the sun's zenith distance would not have been observed. In actual practice, such a circle would be so large that its construction would be impractical. But the approximate position of the vessel is always known, so a small section of the circle is all that is needed. It closely approximates a straight line—the Sumner line of position, as the Salem master's calculations showed.

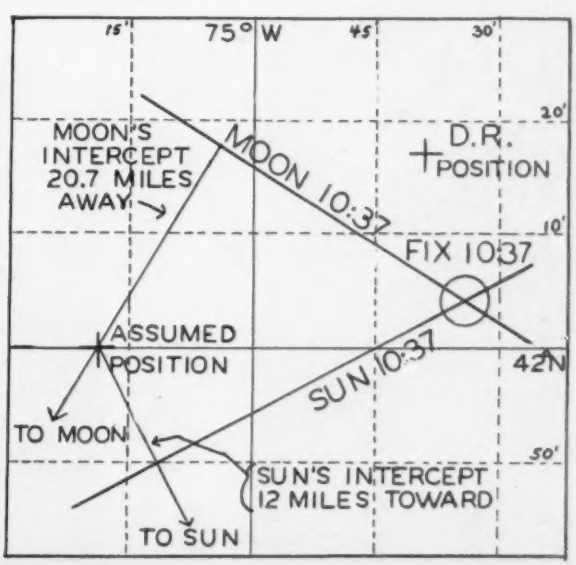
The accuracy with which the sun's altitude is measured determines the accuracy of the line of position. The sextant used for this measurement was first developed by John Hadley in 1731. In its present form, angles as small as 10 seconds of arc can be measured. This is the angular size of a penny seen from a distance of a quarter of a mile. In general, the mariner is able actually to make the measurement to one or two minutes of arc (one or two nautical miles), but this depends upon the condition of the sea and the steadiness of the ship. Observations from a rolling destroyer are not likely to be as accurate as those from a battleship.

Aviators flying over land or above clouds cannot use the marine-type sextant for they have no good horizon to observe. Instead, they use the bubble octant; it contains a bubble which acts as an artificial horizon. Such an octant is more complicated than an ordinary sextant, and consequently, more costly. Moreover, it is not capable of the accuracy of a marine-type sextant; five minutes of arc, or five nautical miles, is the best to be expected, and from an unsteady aircraft the error may easily run to 15 or 20 miles.

Since the graphical method of locating the circle of position is impractical, a computational method is used. The information on hand is the latitude and longitude of the subsolar point (from the *Almanac* and the chronometer) and the distance of the observer from that point (the observed zenith distance). However, to compute the location of a portion of the line of position, additional information must be available. The navigator always has some idea of his position—his *dead reckoning position* based on the courses and distances traveled—and this he can use. The problem is then resolved into the solution of the *astronomical triangle*, which, "brought down to earth," has the subsolar point at one vertex, the dead reckoning position at another, and the pole of the earth at the third.

Assuming his dead reckoning latitude to be correct gives the navigator one side of the astronomical triangle; the declination of the sun and the observed zenith distance furnish the other two sides. In spherical triangles as well as plane triangles, three sides are all that are needed to solve for the three angles. One of these is the angle at the pole,[2] which is the difference between the longitude of the subsolar point and the longitude of a point on the line of position. This point may now be plotted using the assumed latitude. A repetition of the calculation with another assumed

[2] $\cos t = \dfrac{\text{cos zen. dist.} - \text{sin lat. sin dec.}}{\text{cos lat. cos dec.}}$



After his computations have been made, using both assumed latitude and assumed longitude, the computed altitudes are compared with the observed ones. Their differences, the intercepts, are plotted as shown here. The lines of position are then drawn perpendicular to the intercepts, and where the two lines cross is the fix—the vessel's position within the errors of observation. To avoid confusion, the times of observations are marked right on the chart.

latitude gives a second point on the line of position, which can then be drawn on the chart. This was the method used by Capt. Sumner described in his report.

The duplication of the Sumner calculation is time consuming, however, and it was soon realized that the line of position ran at right angles to the line joining the assumed position and the subsolar point. The direction of the subsolar point, usually called angle Z[3] and measured from the north or south point of the horizon, is easily computed and can be laid off on the chart.

It is important to note that in Sumner's method the actual observation is included in the calculations, so the line of position is as close to the real position of the ship as the observation permits. Sumner's method remains fundamental and correct, but another method is now generally used because it facilitates the practical work.

The newer method was first published in 1875, by Marcq Saint-Hilaire, of the French Navy. *Both* the latitude and longitude are assumed, as close as convenient to the dead reckoning position, and the altitude[4] of the body as it would be observed from the assumed position is computed. Now if the actual line of position passed through the assumed position, the computed altitude would equal the observed altitude of the body. But generally they differ by a quantity called the *intercept*. If the calculated altitude is less than that observed, the line of position lies toward the subsolar point from the assumed position, by the amount of the intercept. If the calculated altitude is greater, the line of position lies away from the subsolar point, by the same amount.

Depending upon how close the vessel's true position is to the assumed position, the intercept will be small or large—one or two nautical miles or more than 20. In any event, it is readily scaled off on the chart and the actual line drawn in. For two different objects observed for a fix, the assumed positions do not have to be the same, which gives great flexibility to the Saint-Hilaire method.

The assumption of both latitude and longitude allows several short cuts in the solution. The latitude can be taken on some whole degree and the difference in longitude (t) can also be made in whole degrees by properly taking the assumed position. Pre-computed solutions, such as those of Ageton and Dreisonstok, can be used in a very few minutes' time. Even shorter solutions are possible using such tables as H.O. 214, in which altitudes and azimuths are directly tabulated. The details of these short cuts will be discussed in a later article in this series.

[3] sin Z = cos dec. sin t. sec alt.

[4] sin alt. = sin lat. sin dec. + cos lat. cos dec. cos t.

ASTRONOMICAL ANECDOTES

ANOTHER CASE—ANOTHER PHOTOGRAPH

FAITHFUL followers of this department may recall that in the March, 1940, issue of The SKY, the adventures of Father Rigge in the courtroom were related. A photograph had been taken, and the time as determined from the shadows in the photograph invalidated the testimony of two witnesses, thus leading to the dismissal of the defendant.

In September of 1941, I was called upon to determine the time of taking of a photograph, in a case involving a suit for physical damages allegedly sustained in an accident which occurred on January 17, 1927. The plaintiff, then a child, claimed that, a short time before noon on that day, he was injured by wires knocked down by the overturning of a crane on the property of the defendant, a power company whose name and location must remain unstated. Why he waited 14 years to make the claim was never divulged!

The attorneys for the defendant consulted me on the general point of determination of the time of taking a photograph, and when I had assured them that it was always possible in theory, and generally so in practice, they gave me a print assertedly made on the morning of the date in question, and asked if I could determine the time of taking it. I might explain that at the time of the alleged accident the defendant was enlarging his power plant; each Monday a progress picture was taken; January 17, 1927, fell on Monday.

The photograph showed the plaintiff's house, in front of which he said he was when he was injured. The defendant confessed that an accident had occurred that day, but on another part of the property, and there was no record of any injury. I studied the photograph, and selected several shadows for use in the problem. Then I visited the scene, and found half the shadows useless because houses and poles had been torn down. One very good shadow remained, but its use was complicated by the fact that it was the shadow of the corner of the eaves of one house, falling on the sloping roof of the porch of another house. (See enlarged detail of the print; A is the shadow of B.)

Two surveyors were put at my disposal, and the three of us spent six hours measuring practically everything in sight for about 200 yards up and down both sides of the street. Buried pavements were uncovered, dilapidated fences were restored, and chalk marks were liberally strewn on the scene. As a final step, we performed a roundabout example, utilizing the shadow of a pole, and noting the time of observation. The computed time differed by only 54 seconds from the observed time; this was a test problem, designed to convince doubting jurors that the method would work.

To make a long story (15 hours of computations!) short, I used the computed altitude and azimuth of the corner of the eaves of one house as seen from the tip of the shadow on the roof of the porch of the other house to derive first approximations to the declination and hour angle of the sun, hence the date and time of day. Two dates were possible, but one was ruled out by the fact that there is snow on the ground, in the picture. The date was January 17th, and the time was approximately 10 a.m. With this, a better value of the sun's declination could be obtained, and this was used first with the computed altitude and next with the computed azimuth of the sun, to derive two independent values of the time. The two values differed by only 36 seconds. The mean of the two was 10:10.9 a.m., E.S.T., and I concluded my computations with this statement:

"The various essential parts of this problem are so interlocked by the method of measurement and the method of computation that this time can not be in error by more than 1 minute; I feel great confidence that the photograph was taken between 10:10 and 10:12 a.m., E.S.T., January 17, 1927."

The photograph shows no crane on the defendant's property, nor any track for a crane to run on, yet within a few minutes of this time the plaintiff claimed to have been injured by the toppling over of a heavy crane on a railroad track.

The case never came to trial. After many postponements, it was settled out of court! R.K.M.

BEGINNER'S PAGE

Meteorites

By Percy W. Witherell

THE large meteorites, often weighing many tons, that are on exhibition in many museums throughout the world are usually composed of very hard nickel-iron. Such a mass of metal attracts attention by its contrast with its surroundings, whereas the more numerous meteorites of stone blend with the landscape and are not easily found unless they are seen to fall. In the densely populated areas of the earth, many of the ancient iron meteorites were utilized by the inhabitants for spear and arrow points, so that the "museum pieces" have generally been found in sparsely settled regions.

The largest known (Hoba West) is located in Grootfontein, South West Africa. It is nine feet by nine feet and three feet high, is 16 per cent nickel, and is estimated to weigh 60 tons. The next largest was found by Admiral Peary in Greenland and is now at the Hayden Planetarium, New York; it weighs 36½ tons. There, also, is the largest that has been found in the United States and the fourth largest in the world, the Willamette of Oregon. Its original weight of 25 tons has been reduced by erosion to 15½ tons.

The third largest (24 tons) is in Bacubirito, Mexico. At least one of the large meteorites of Mexico was known to the Spanish conquistadores, and some were venerated in the temples of the Aztecs. The sacred black Kaaba at Mecca is a meteorite, and there are numerous sacred stones mentioned by Chinese, Greek, and Roman writers that were probably of meteoritic origin.

When a mass of many thousand tons strikes the earth with high velocity, the kinetic energy of its motion is converted into an explosive force that excavates an enormous crater, and throws up its former contents into a rim of great size, crushing and fusing the rock in all directions.

The most famous meteor crater is in Arizona, with a circular diameter of 4,000 feet, a rim of 120 feet above the surrounding plain and extending 2,000 feet, and a depth below the rim of 600 feet. Debris from this crater has been found several miles distant and buried to depths of 10 feet.

Craters in many other parts of the world are undoubtedly of meteoritic origin. Some, however, have been nearly obliterated by the lapse of time, although the effects of the explosion may be seen for many miles. A notable example is the blast which shook Siberia in 1908, producing barometric and seismographic effects in England. Often multiple craters have been found which indicate the arrival of numerous bodies from space.

How hot is a meteorite? Some iron meteorites which have been found at the time of their fall have been too hot to handle, but there is no authentic record of their charring or igniting inflammable material. The stony ones are seldom more than lukewarm. The heat caused by friction with the atmosphere is sufficient to melt the outer, forward surface of a meteorite, so that fused iron or glass is found on the surface, but this is only skin deep and the greater part of the mass remains at a moderate temperature.

The size of this meteorite is given by the 18-inch rule.

What is the origin of a meteorite? The latest investigations of the composition of the atoms found in meteorites and in the earth show them to be of the same age. The speeds of falling meteorites prove them to be part of the solar system. The range of their makeup, from nickel-iron to stone with all the proportions in between, is somewhat similar to the variation in material from the iron core of the earth to its granite surface. These facts suggest the possibility that meteorites and asteroids are the remains of a planet that may have once traveled in an orbit between those of Mars and Jupiter and exploded in some super-Jovian catastrophe.

Rising about 120 feet above the surface of its desert surroundings, the rim of Meteor Crater runs in a raised circle some three miles in circumference.

AUTUMN SKI

By William H. Barton, Jr.

A good deal can be learned from the stars which is of value in e ing and of especial value during wartime. Here and in the Ha tarium this month, many examples of the practical uses of the sta

IF you step outdoors at 8 o'clock on the evening of September 1st and look exactly overhead, you will find shining there the brightest star that we see in the summer sky—Vega, in the constellation, Lyra. Smooth as this statement sounds, exception can be taken to it. And I must admit it is a trifle vague. The first question might arise as to the kind of time referred to. In general, with standard time, and now, with war time, we do have to be careful.

The time mentioned above is technically called local time, that is, it is time referred to the observer's meridian —the local meridian. This, of course, is not what the clock says. It is what the sundial says, or nearly so. But in our practical world we are past the age of sundials. Seventy years ago we agreed to use only the time along certain meridians, zoning the world into one-hour bands. From the eastern tip of Maine to Grand Rapids we use the time of the meridian that runs through Philadelphia. Eastport, Me., is in longitude 67° west and Grand Rapids is nearly 86° west. The sun crosses the south point in the sky of Eastport about a half hour before it is in the south of the Philadelphia sky, and three quarters of an hour more elapses before it reaches Grand Rapids' meridian. And yet the noon whistles in the three cities blow at the same instant. Local time often differs from standard time by half or three quarters of an hour or more. Hence the star, Vega, may not be exactly in the zenith, according to your standard-time clock, but it will probably be within half or three quarters of an hour of the overhead point.

With daylight saving or war time changing standard time by an hour, another discrepancy is introduced into the problem. So with these reservations in mind and due allowance being made for them, we repeat:

If you step outdoors at 8 o'clock on the evening of September 1st and look exactly overhead . . . . But before you do that there is something else we should consider—your latitude—because your position on the earth determines the appearance of your sky.

If we look up the position of the star, Vega, in the *American Nautical Almanac* for 1942, we find its declination to be +38° 44′. That is, the star is nearly 39 degrees north of an imaginary line in the sky which astronomers call the celestial equator and the navigators know as the equinoctial. Declination in the sky is equivalent to latitude on the earth, each measured by degrees north or south of the equator. The celestial equator is exactly above the equator of the earth, so a star located on it will cross the zenith of observers along the terrestrial equator. A star that is 10 degrees north of the celestial equator will cross the zenith of places 10 degrees north in latitude. Therefore, Vega, with a north declination of +38° 44′, will pass exactly overhead in latitude 38° 44′ north.

All across the United States, along this parallel of latitude, the star will shine exactly in the zenith—across Maryland just below Annapolis, a little south of Washington, through West Virginia, across the Kansas prairies, over Colorado, and just north of Sacramento.

A landlocked navigator practicing with his sextant, just to keep his hand in, might find Vega to have an altitude of 90 degrees above the horizon of the prairies at the time we have specified (if he could see the horizon at night). That is, when the star is exactly on his meridian, it will be exactly in his zenith. He would describe himself as being at the *geographical position* of Vega, and thus would tell you his latitude and longitude. And that is what a navigator wants to know frequently.

If our land navigator were one geographical mile north of latitude 38° 44′, Vega would cross the meridian one minute of arc south of the zenith; two miles, two minutes, and so on. And if he were to the south of 38° 44′, Vega would pass north of his zenith. Therefore, an observer who finds Vega passing three minutes north of the zenith (at an altitude of 89° 57′) knows immediately that he is at latitude 38° 41′ (latitude of St. Louis, Mo.). That, of course, is only the start of the story, told in this issue by Dr. Fletcher Watson, of making

A constellation chart of the 19th century is still useful for autumn stargazing. Note the celestial equator is labeled EQUINOCTIAL.

KIES

value in everyday living in the Hayden Planes of the stars are given.

Northern observers generally see Pegasus, the Winged Horse, upside down—he looks like this from southerly regions. Enif is in his nose; the Water Jar of Aquarius is above his head.

a celestial *fix* in navigation, and we started out to describe the autumn sky. So again we say:

If you step outdoors at 8 o'clock on the evening of September 1st and look (not exactly, probably!) overhead, you will find shining there the brightest star that we see in the summer sky. Vega is a blue-white star of magnitude 0.1. It is exceeded in brightness by only three stars, Sirius, Canopus, and Alpha Centauri. Neither Canopus nor Alpha Centauri is visible in this latitude, but Sirius can be seen during winter evenings. At the current season of the year the sun is leaving the part of the sky where Sirius is located—the Dog Star rises in the morning from two to four hours ahead of the sun, depending on your latitude.

Vega is in the constellation Lyra, the Lyre. Near it are a pair of stars that form with it a small equilateral triangle. Neither of these is very bright, but the triangle can be picked out on a dark night. One of the stars is to the east and the other to the northeast. The latter is Epsilon Lyrae, a famous double star. It is remarkable in that the separation of the components is just on the limit of vision. That is, a person with keen eyesight can separate the stars, but the average person cannot. The angular distance between them is about 3.5 minutes of arc, about twice the amount that Uranus was out of its computed position a century ago. This discrepancy, you remember, led to the discovery of Neptune by mathematical prediction. Even an opera glass will easily separate these two stars in Lyra. But a moderate sized telescope will reveal each component to be a pair of stars—Epsilon Lyrae is often called a "double double."

Sagittarius star clouds.

With Lyra as a starting point, it is easy to find the Milky Way running from northeast to south. Along this path of light just to the east of Vega you can find the Northern Cross, the top of the Cross marked by the bright star, Deneb, to the north, and the foot of the Cross, by Albireo in the south.

Deneb is remarkable in that it is so distant, yet so bright. Dr. Peter van de Kamp gives its distance as about 400 light-years. Its luminosity is estimated at 4,800 times that of our sun.

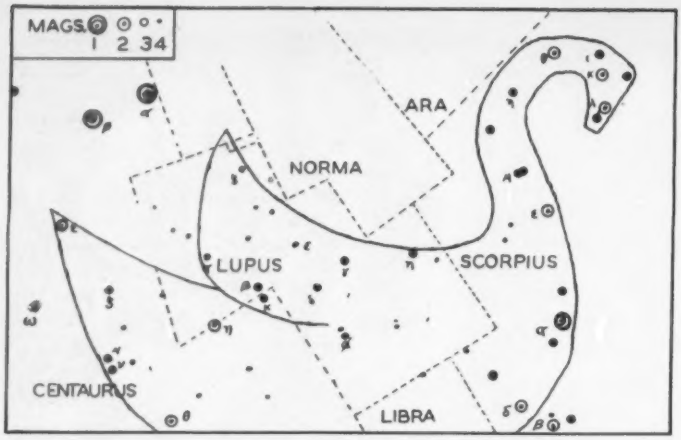
Albireo, at the foot of the Cross, is a very beautiful double star when viewed in a telescope. One component is blue and the other orange or golden.

Many people who possess spyglasses or good field glasses or binoculars fail to appreciate how much hidden beauty they will reveal. Fields of tiny stars along the Milky Way look like diamond dust on black velvet; fields in which there are no visible stars look like black, empty space; hazy, nebulous patches are found; other similarly appearing fields are universes of stars so distant that ordinary telescopes cannot resolve them; bright stars appear in the field and startle the observer; beautifully colored pairs, such as Albireo, are numerous.

Just across the Milky Way from Vega, you will find the bright star, Altair, in Aquila, the Eagle. This white star and Deneb and Vega form a nearly isosceles triangle. There is no mistaking Altair, as it is flanked by two dimmer stars, the three forming a straight line.

Toward the foot of the Milky Way and just above the southern horizon, you can see Sagittarius, the Archer. It is a rather conspicuous group even though it does not contain a single 1st-magnitude star. There are a great many stars of medium brightness and they are arranged in patterns easy to follow. Some observers readily trace out the original archer drawn there by the ancients. Others note the milk dipper, the third dipper in the sky, and still others see a teapot, with its spout pouring tea on the tail of the Scorpion, immediately to the west of Sagittarius.

Scorpius, itself, is an important star group and one that is of definite form—it looks remarkably like the object for which it is named. Although Cygnus is the Swan, its arrangement of stars does not suggest a swan swimming in the water—the celestial swan is supposed to be flying down the Milky Way. But if you go to about 40 degrees south latitude, where the Scorpion is turned upside down, you can really trace a swan



From about 40° south latitude, when Fomalhaut is on the meridian, "Cygnus Australis" may be seen along the southwestern horizon. You may want to include Alpha and Beta Centauri, which would give this "constellation" three 1st-magnitude stars, more than any real one has.

in the sky, with its gracefully curved neck (the tail of Scorpius) in the conventional posture.

Had the constellations been first named by peoples of the Southern Hemisphere, the group would no doubt have received the name "Cygnus Australis," the Southern Swan, made up by stars in Scorpius, Lupus, and part of Centaurus.

The bright, reddish star in Scorpius is Antares. The name means *rival of Mars*, because the star's color is very much like that of the planet. Sometimes the latter passes not far from Antares, because Scorpius is one of the zodiacal constellations. Antares is a red-giant star and one of the largest that has been measured. It is 280 million miles in diameter (a figure which recent observations have reduced from one nearly twice as large). If the sun were placed at Antares' center, the orbit of Mars would lie on the surface of the star, with the earth well inside.

Just above the eastern horizon, the Great Square of Pegasus is rising on one corner. It sets on the other corner. The star pointing toward the south as it rises is Markab, and that pointing north is Alpheratz. Strictly speaking, this latter star really belongs to Andromeda, and is merely borrowed to "make a fourth" in the Square. Were it not for this ancient practice of lend-lease, there would be no Great Square of Pegasus.

Within the Square the sky looks barren unless your seeing is good. There are, however, about 13 stars there brighter than magnitude 6.0, and therefore visible to the naked eye. Almost midway between Altair and Markab is another bright star belonging to Pegasus; it is called Enif, and is in Pegasus' nose. The Flying Horse is one of the star groups which appear upright to observers in the Southern Hemisphere.

Low in the western sky you will find the bright Arcturus, a star that is much better known than the group to which it belongs—Boötes, the Herdsman. Between Arcturus and Vega, a small, semicircular group bears the name of Corona Borealis, the Northern Crown. One star is considerably brighter than the others, and is sometimes called Gemma. Then again, it is called Alphecca, which means "The Bright One of the Dish."

Along the Milky Way toward the northeast we can see the W of Cassiopeia. This, too, has three named stars that turn out to be fairly well known, and one other. At the western (top) point of the W is Caph (Beta), and the bottom of the western part is Schedar (Alpha). In the middle is the famous Gamma Cass. (See *Sky and Telescope*, July, 1942.) The next star in the W is Ruchbah (Delta).

In the northwest, the Big Dipper is approaching the horizon line, and between it and Cassiopeia is the Little Dipper. But almost everyone can point out the star in the Little Dipper that is at the end of its handle—Polaris, the north star. This star is not exactly at the pole of the sky, but just a degree away from it. About 22 centuries ago, the Greek astronomer and navigator, Pytheas of Massilia, noted that the pole was not fixed among the stars. At present it is moving toward Polaris, but will never quite reach it.

But who knows the names of the two fairly bright stars in the bowl of the Little Dipper? They are frequently referred to as "guardians" or "guardsmen." Old Thomas Hood derives them "of the Spanish word guardare, which is to behold, because they were diligently to be looked unto, in regard of the singular use they have in navigation." Shakespeare, in Othello, mentions them:

The wind-shak'd surge, with high and monstrous mane
Seems to cast water on the burning Bear,
And quench the guards of th' ever fixed pole.

To the common people of old these stars were a timepiece marking off the hours of the night. But their names? The one toward the north is Kochab, and the dimmer one to the south, Pherkab, which, for those who have a telescope, is a double star.

In the days of the early Egyptians and the Pyramids, Thuban, in Draco, marked the pole of the heavens, and in the years to come other stars will take their places in turn. Vega and Deneb will be near the pole after 10,000 years and more have passed, as *precession* swings the pole of the sky around in a huge circle against the background of the stars. Thuban is situated between the bowl of the Little Dipper and the handle of the Big Dipper.

The Big Dipper is probably the most familiar group of stars in the sky. The seven stars forming it have interesting names. The two in the front of the bowl are the Pointers, because they are nearly in line with the pole star. Their names are Dubhe and Merak, the former being closer to the pole. Phecda and Megrez, the latter fainter, form the rest of the bowl. The three stars in the handle are Alioth, Mizar, and Alkaid.

Of all these, Mizar is probably the best known. It is famous for its 5th-magnitude companion, Alcor. To the Arabs these were a test of eyesight and called the Horse and Rider. Mizar is itself double when seen through a telescope. In fact, it was the first star to be discovered as a double, and the first one to be successfully photographed. When spectroscopy of the stars began, each one of the Mizar pair turned out to be a spectroscopic double, and again one of them was the first of the kind discovered. So Mizar and Alcor, which may appear as a single star to a casual observer, turn out to be a whole family of stars.

In scanning the September sky we have named 25 stars. Besides eight in Ursa Major, and three each in Ursa Minor and Cassiopeia, they are:

Vega in Lyra
Deneb in Cygnus
Albireo in Cygnus
Altair in Aquila
Antares in Scorpius
Markab in Pegasus
Enif in Pegasus
Alpheratz in Andromeda
Arcturus in Boötes
Alphecca in Corona
Thuban (4th mag.) in Draco

At one time and place, then, we can see these 25 stars and many more that have names well known to most students of the sky. But today we are interested in practical things. There is a war and all our energy is needed to win it. Of what use is gazing at the sky and calling the stars by name?

If you open the *American Nautical Almanac* for 1942 to page 162, or look inside the back cover of this year's *American Air Almanac*, you will find a list of 55 stars used by the navigator on the sea or in the air. Of our 25 stars, only nine are not among those famous 55 navigational stars. Four of these nine are in the Big Dipper. But Albireo, Pherkab, and Alkaid are in the supplementary list of additional stars found on page 218 in the *Nautical Almanac*. Yes, constellation study has its place in defense.

Amateur Astronomers

AN AMATEUR'S NEW OBSERVATORY

By Louis E. Bier

FOR three years, an amateur astronomer, Roelof Weertman, of Beaver, Pa., dreamed, planned, and toiled, that his one all-consuming ambition might be realized; and then on the 23rd of June, 1942, came one of the really important events of his life: the completion and dedication of his 12½-inch telescope and observatory.

Situated on a hill above his home—above the mist that rises in the valley of the Ohio River—the observatory is visible for many miles in several directions. Already the eminence is coming to be known as Observatory Hill. Mr. Weertman is a Hollander and the Dutch aspect seems to be reflected in his handiwork. From afar, the white dome surmounting the observatory, with the welded steel-framework tube, resembles an old Dutch windmill. However, there are only two sails instead of the regular four.

Any amateur astronomer who has constructed a 6-inch portable telescope, with the planning and effort in which he found himself involved, may readily appreciate the magnitude of Mr. Weertman's undertaking. It was necessary to carry all of the material, about 12 tons, up a steep ascent of 200 feet. The contemplation of this part of the task alone would have deterred many a less ardent follower of the hobby. But now the job is complete, and what does the Pennsylvania amateur have?

The telescope mirror is an f/9, of 110 inches focal length; its figure was checked by Norbert Schell, of the A.A.A. of Pittsburgh. The novel Newtonian mounting permits inside observation in cold weather, a feature surely welcome when Orion stalks across the cold, clear heavens of winter. To reach the eyepiece; the observer ascends into the dome via four or five steps. A trapdoor is located directly above the stairway, and when closed forms one half of the observation platform. This provides ample room for two persons in the observing dome at a time.

The right ascension movement is provided by the revolving dome or *turret*, which is inclined at an angle equal to the colatitude, about 49½ degrees. This turret travels on roller bearings and carries the telescope, which is balanced on a hollow pivot forming the declination axis. A 2½-inch diagonal and the eyepiece position are consequently also located at this pivot. Setting circles are plainly visible and easily set in motion by turning auto-door handles connected to the necessary gears. The eyepiece does not rise more than a foot above the east or west positions. The inside of the dome is marked with latitude and longitude circles, while various stars and nebulae are superimposed thereon.

The main room of the observatory is large enough to accommodate a cot, and the Weertmans plan to sleep here on nights when astronomical events of special interest to them occur. What amateur astronomer would not delight in such a convenience? An alarm clock to awaken one at the proper time; and then simply to climb a few steps to start observing is real convenience.

The opening and dedication on the evening of June 23rd was attended by many members of the A.A.A. of Pittsburgh. Mr. C. A. Atwell, our president, acting as master of ceremonies, read a number of congratulatory telegrams and letters from members and friends who were unable to attend. A poem, penned by Mr. Atwell to suit the occasion, was read, and will be permanently framed in the observatory. Mr. Weertman treasures a register book signed by all present. Observations were made on the first-quarter moon and other objects until the sky went bad about 10 p.m. Among the delicious refreshments served by Mrs. Weertman were cookies cut to form stars, crescent moons, and other celestial objects.

This installation adds one more to the growing number of amateur observatories in the Pittsburgh district. They are evidence of an increasing interest in astronomy which should extend far into the more peaceful years of the future.

Amateurs who have been to Stellafane (Springfield, Vt.), are acquainted with the turret-type telescope, of which Mr. Weertman's is the latest example. The Pennsylvania amateur here stands in front of his new observatory.

NEW YORK 1942-1943 SEASON OPENS

A FIELD trip to Long Island to observe and photograph the August eclipse of the moon was a prelude to another season of constant activity by members of the Amateur Astronomers Association in New York. Over Labor Day weekend, September 4-7th, members and their guests will have three days of outdoor fun—astronomical and otherwise—at the Blue Mountain Trail Lodge in Peekskill, N. Y., for the fifth year in succession.

The Trail Lodge has a large recreation room with open fireplace, a huge kitchen, two large dormitories, and spacious grounds. After informal days given to summer sport (including solar observations) the nights are spent counting the stars.

Other amateur societies may find similar sites available in their respective localities, in which event we shall be glad to exchange experiences and ideas. These early-season outings stimulate interest in classes, lectures, and later field trips.

Our regular series of bi-monthly meetings will begin October 7th, when Dr. Roy K. Marshall, of the Fels Planetarium, will speak on *Astronomy in the Service of Culture*; on October 21st, Dr. Lyman A. Spitzer, on leave from Yale University, talks about *The Origin of the Solar System*. Future talks are on calendar reform, international astronomy, the Einstein theory, and astronomical photography.

Among our classes this year are new ones: Astronomical Photography, by Peter A. Leavens; Meteorology, by Jane Burden; also, possibly, Navigation, and Optics and Optical Instruments. Regular classes will be held in Elementary Astronomy, by Meyer Meadow; Advanced Astronomy, by Jane Davis; and Mathematics Survey, by Max Trupin. The final schedule will be announced in our circular, *Enjoy the Stars*.

All interested persons are invited to write to the undersigned for details on membership in this society, for which the regular annual dues are three dollars.

GEORGE V. PLACHY, secretary
Amateur Astronomers Association

CONFERENCE ON SPECTROSCOPY

Among the papers presented at a conference on spectroscopy conducted by the University of Chicago on June 22nd-25th, several were of astronomical import. One afternoon session was devoted to the spectra of comets, and a morning session to the earth's atmosphere and the constitution of the planets. Other papers, not strictly astronomical, but of importance to astronomers, concerned primary standards of wave length (work in which the International Astronomical Union had taken part); spectra of the rare earths; and the generalized theory of concave gratings. This last will prove valuable in its application to the big Coude gratings used at Mt. Wilson and McDonald Observatories in obtaining stellar spectra of high dispersion.

Dr. P. Swings, of Yerkes Observatory, spoke on the identification of molecular bands observed in the spectra of comets. Most of the molecules definitely identified are simple diatomic, that is, composed of two atoms each. The elements, oxygen, carbon, nitrogen, and hydrogen, combine to form OH, NH, CN, CH, C_2, CH+, CO+, and N_2. Gases occluded in meteorites were cautiously mentioned as providing possible clues to the gaseous constituents of cometary atmospheres. The most difficult feature to interpret has been a band group near wave length 4050 angstroms. Its intensity varies with the distance of the comet from the sun. This band is absent from spectra of cool stars, and it has not been found in interstellar space. No simple diatomic molecule has been found that would explain all of these astronomical observations.

On physical grounds, Dr. G. Hertzberg, of the University of Saskatchewan, likewise found that no diatomic molecule could adequately account for the observed appearance of comets' spectra. He suggested the triatomic molecule, CH_2, which qualitatively accounts for Dr. Swings' observations. More specific conclusions must await results from physics laboratories on the details of the spectrum of CH_2.

Fluorescence, excited by solar radiation, produces the emission in cometary spectra, according to Dr. Swings. For various reasons, such induced radiations do not correspond in position and intensity of spectral lines precisely to those in laboratory spectra. Thus exact identification becomes a complex problem depending on a knowledge of the relative velocities of the comet and the sun, and the distribution of light in the solar spectrum and in the laboratory spectra of the suspected molecules.

Dr. Andrew McKellar, of the Dominion Astrophysical Observatory, has made a critical study of the intensities of bands in the spectra of Comet Hassel (1939d) and Comet Cunningham (1940c). These bands correspond to temperatures ranging roughly from 200° to 2,000° K., an anomaly which requires further study.

The recent advances in the interpretation of cometary spectra, as shown by these papers, illustrate once more the fruitfulness of close cooperation between physicists and astronomers.

The origin of the planets remains an unsolved mystery. Yet one phase of their evolution after their creation seems definite: on the basis of empirical evidence it has become "one of the axioms of modern geochemistry that the earth and planets alike were started on their evolutionary course as homogeneous fluid masses many thousands of degrees hot." What have been the causes of the striking dissimilarities of their present *superficial* constitutions? This is the problem that Dr. Rupert Wildt, of Princeton University, discussed in his paper, "The Geochemistry of the Atmosphere in Relation to the Constitution of the Terrestrial Planets."

The earliest era in the cooling of a planet ended with the onset of condensation, producing a liquid core surrounded by a deep, dense atmosphere. The second period saw large-scale fractional crystallization of the silicates (formation of granitic rocks). The unique position of the rare earths (the mother substances of the natural radioactive series) in the uppermost crust of the earth's lithosphere is qualitatively explained on geochemical principles. Because of the high atomic weights of these elements, we should have expected them to be concentrated at much greater depths—settled toward the center during the first era rather than deposited as minerals of the second.

The escape of helium, hydrogen, and other light elements from the atmospheres of the inner planets has often been discussed. The problem that now concerns us more fully is the source and distribution of water vapor and free oxygen, abundant here on the earth but scarce on Mars and Venus. The loss of water vapor on Mars is readily attributed to the low force of gravity on that planet. Venus, however, presents a baffling problem. Dr. Wildt said, "With masses and mean densities of the Earth and Venus so nearly equal, one is reluctant to abandon the hypothesis of a similar constitution for their bulk." The only explanation that suggested itself to him for the absence of a conspicuous hydrosphere on Venus is that such a deficiency existed when the planet was born—considering that oxygen and hydrogen are involved, this is an unsatisfactory proposal.

Dr. Wildt, discussing theories for the development of large quantities of free oxygen in our atmosphere, concludes that the *simultaneous* absence of water vapor and free oxygen on Venus is really plausible, for the oxygen may have been consumed by oxidation of the liquid magma at the planet's surface. Similarly, on Mars, while its atmosphere is now devoid of oxygen, there must have been at one time enough to form the reddish oxidized surfaces that we observe.

Spectrophotometric and photoelectric studies of the light of the night sky were reported on by Dr. C. T. Elvey, of McDonald Observatory. Two kinds of night-sky illumination are observed: the brilliant aurorae or northern and southern lights, and another more common but less spectacular radiation, called the permanent or "non-polar" aurora. This latter was the subject of Dr. Elvey's paper. The spectra indicate that atoms or molecules of oxygen, sodium, nitrogen, NO, water (H_2O), and sometimes ionized nitrogen are involved.

The spectrophotometric studies, in which Dr. Alice Farnsworth, of Mt. Holyoke, collaborated, refer to radiations originating about 800 miles above the earth's surface. The photoelectric observations concern radiations from altitudes of about 200 miles.

Infrared observations of the intensity of the light of the night sky show a steady decrease throughout the night on some nights. Such observations are associated with times when terrestrial magnetic activity is low. When the magnetic activity increases, irregular variations are apparently superimposed on the usual steady variation of nocturnal intensity, finally masking the steady trend altogether. These irregular variations are, moreover, unlike in different parts of the sky. The regular variation may be explained on the theory that the radiation is caused by the release of energy when oxygen atoms combine to form oxygen molecules. The irregular variations are more difficult to interpret. It is suggested they are aurorae too faint to be observed by the unaided eye.

DORRIT HOFFLEIT

Modern spectral studies help solve the mystery of comets.

NEWS NOTES

(Continued from page 6)

ficial moon placed at a standard distance. The size of the artificial moon could be varied to appear to agree with the actual moon. The orientation of the observer's head was controlled by means of a "biting board," so that the angle between direct vision and the elevation of the moon was measurable. While viewing the moon, observers sometimes sat up, sometimes lay down.

The real moon has a diameter of about half a degree. Compared with the artificial moon at a distance of 12 feet, it appeared anywhere from two to six degrees in diameter to people with normal vision using both eyes. Congenitally monocular persons, uninfluenced by knowledge of the illusion, did not perceive it.

The experiments conducted at the Psychological Laboratory were intended to choose among four modern theories, all having to do with the physiology of the eye. Already out of consideration was the old-fashioned explanation that the moon is contrasted with terrestrial objects when near the horizon. Also taboo was the theory that the celestial sphere appears flattened overhead, and the apparent distance of the moon therefore varies.

Of the four modern theories, however, only Ames' theory of ocular torsion is not finally rejected. When the eyes are raised, the right eye tends to rotate clockwise (as seen from behind) with respect to the left eye, and this factor may explain the moon illusion for binocular vision. But the results are not conclusive.

DO YOU KNOW?

By L. J. Lafleur

I. Score four points for each question answered correctly, and one point for each question where you do not attempt to select the answer.

1. One of the following constellations does not contain part of the Milky Way:
   a. Leo c. Scorpius
   b. Lupus d. Sagittarius

2. The butterfly diagram has reference to the
   a. main sequence
   b. galaxy distribution
   c. spark spectrum contours
   d. sunspot cycle

3. The latitude of an observer is the same as the apparent altitude of the celestial pole. The latitude here referred to is
   a. geocentric c. geophysical
   b. geographic d. astronomical

4. Variations in length, mass, and time, are described in the transformations of
   a. Newton c. Jeans
   b. Tycho d. Lorenz

5. One of the following events is impossible:
   a. Mercury appears in Auriga
   b. Mars appears in Perseus
   c. Saturn appears in Sextans
   d. Jupiter appears in Cetus

6. Near the poles, a degree of geographic latitude, compared to a degree of geocentric latitude, is
   a. longer b. shorter c. equal
   d. longer near the north pole, shorter near the south

7. A millionth of a millimeter is indicated by the symbol
   a. mμ b. mλ c. μ d. μμ

8. The black drop is a phenomenon observed in connection with
   a. transits c. meteors
   b. eclipses d. novae

9. Because of atmospheric refraction, stars appear
   a. higher c. larger
   b. lower d. smaller

10. There is no 1st-magnitude star in
    a. Taurus c. Ursa Major
    b. Eridanus d. Boötes

II. Each of the following figures is important in astronomy. Can you identify them? Count five points for each one identified.

a. 50.2 c. .01673 e. 0".761
b. 20 d. 3.259 f. 3969

III. Count 10 points for each question you answer correctly.

1. If we could produce a ship to travel in interplanetary space, there would be only one practicable method of controlling speed and direction from inside the ship. On what principle would we depend?

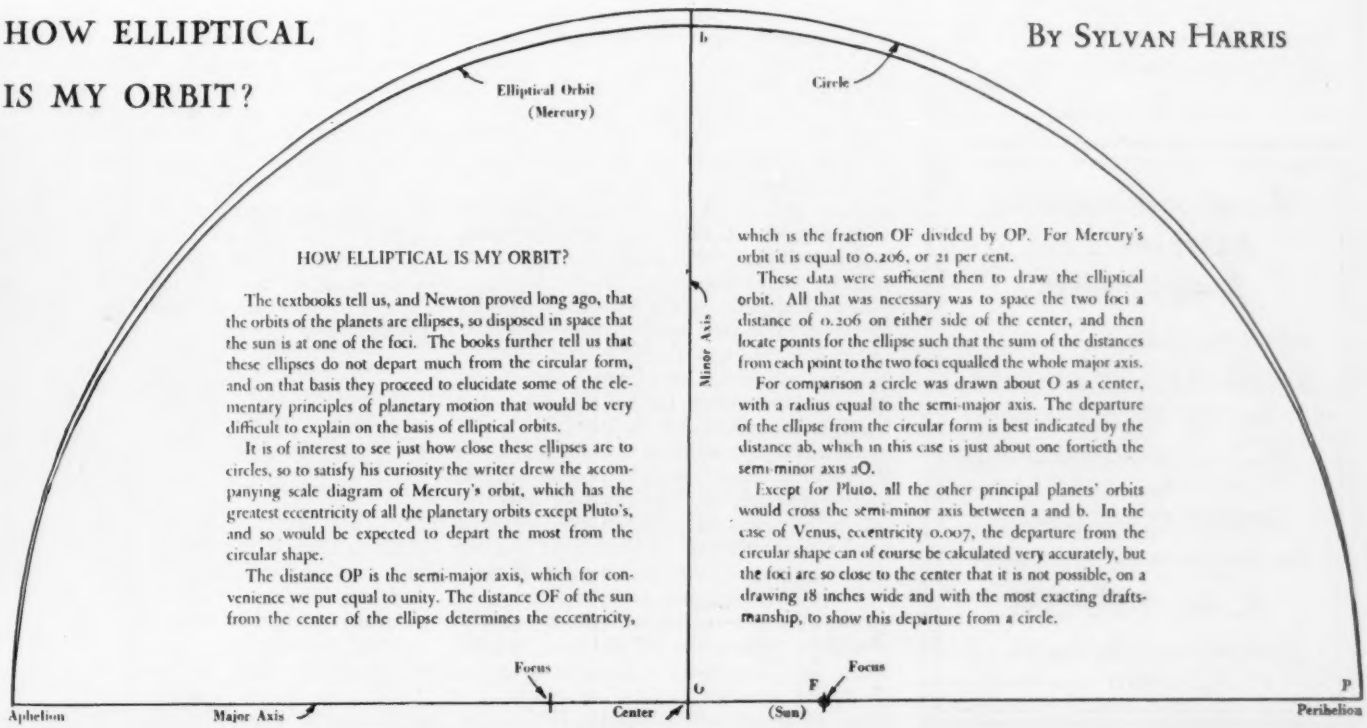
2. How should it be installed?

3. Another method is theoretically available although completely impracticable. What is it?

(Answers on page 20)

HOW ELLIPTICAL IS MY ORBIT?

By Sylvan Harris



HOW ELLIPTICAL IS MY ORBIT?

The textbooks tell us, and Newton proved long ago, that the orbits of the planets are ellipses, so disposed in space that the sun is at one of the foci. The books further tell us that these ellipses do not depart much from the circular form, and on that basis they proceed to elucidate some of the elementary principles of planetary motion that would be very difficult to explain on the basis of elliptical orbits.

It is of interest to see just how close these ellipses are to circles, so to satisfy his curiosity the writer drew the accompanying scale diagram of Mercury's orbit, which has the greatest eccentricity of all the planetary orbits except Pluto's, and so would be expected to depart the most from the circular shape.

The distance OP is the semi-major axis, which for convenience we put equal to unity. The distance OF of the sun from the center of the ellipse determines the eccentricity, which is the fraction OF divided by OP. For Mercury's orbit it is equal to 0.206, or 21 per cent.

These data were sufficient then to draw the elliptical orbit. All that was necessary was to space the two foci a distance of 0.206 on either side of the center, and then locate points for the ellipse such that the sum of the distances from each point to the two foci equalled the whole major axis.

For comparison a circle was drawn about O as a center, with a radius equal to the semi-major axis. The departure of the ellipse from the circular form is best indicated by the distance ab, which in this case is just about one fortieth the semi-minor axis aO.

Except for Pluto, all the other principal planets' orbits would cross the semi-minor axis between a and b. In the case of Venus, eccentricity 0.007, the departure from the circular shape can of course be calculated very accurately, but the foci are so close to the center that it is not possible, on a drawing 18 inches wide and with the most exacting draftsmanship, to show this departure from a circle.

GLEANINGS FOR A. T. M.s

EDITED BY EARLE B. BROWN

MAKE YOUR OWN SPECTROSCOPE

SINCE telescope-making activity is probably curtailed by the war, now is the time to use up those spare parts and odds and ends lying about the shop, to build a few accessories.

Spectroscopy plays such a large part in modern astronomy that the amateur astronomer ought to be in a position to learn something about it first-hand, especially when it is not so difficult a job to build a spectroscope of considerable power.

The requirements are a dispersing element, two small achromatic lenses, an eyepiece, and a few odd pieces of metal, plus a little mechanical ingenuity.

The dispersing element can be either a prism or a diffraction grating. A replica grating of about 15,000 lines per inch can be purchased at a scientific supply house for two or three dollars, and will give excellent spectra, quite satisfactory for anything except quantitative work. If the amateur can secure a 60-degree flint glass prism, it will probably be more satisfactory, since the diffraction grating is too wasteful of light for use on stars with anything less than a 12-inch telescope, and then only on the very brightest. For the sun, the grating is much superior. If desired, the instrument may be constructed so as to be interchangeable for prism or grating.

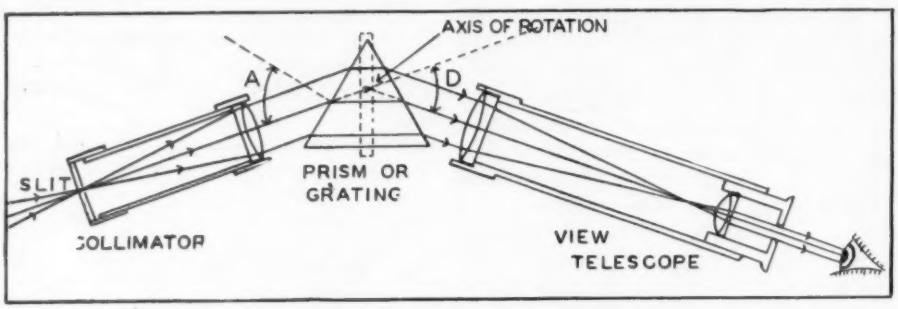
The lenses should be of short focal length, since if the instrument is to be mounted on the telescope, it must be kept as compact as possible. It is not absolutely essential that the lenses be achromatic, but there may be some difficulty in focusing if they are not. The eyepiece should be of about ½-inch focal length, since we want considerable magnification, but must not reduce our field too much. The lenses should be equal in diameter to the width of the prism face—not greater, since we would then waste much of the light. It is better to have them too small. Larger lenses can be diaphragmed down to the proper size.

There will be five principal parts to our spectroscope: slit, collimator, prism or grating mounting, view telescope, and spectroscope mounting.

Slit. This will be the most difficult part to make. The two leaves should have perfectly straight, smooth edges, and must be mounted parallel. One of the leaves should be so mounted as to be adjustable for varying the width of the slit. It is not possible for the amateur to make the slit leaves smooth and straight in the original cutting operation. They must be mounted side by side, and the edges carefully ground until they can be closed light-tight without pressure. A good device is a piece of cloth impregnated with fine carborundum. The actual surface of contact of the two leaves should be very nearly, but not quite, a knife edge. Steel is probably the best material. A sliding arrangement can be made of a few odd pieces and a knurled-head screw.

Collimator. Use the lens of shorter focal length for the collimator. A metal tube is prepared so that the slit can be mounted at the opposite end from the lens, and at its principal focus. The collimator tube should be carefully blackened inside with *flat* black paint. If the inside surface is roughened in some way, the effect of the blackening will be enhanced. The collimator is attached rigidly to the mounting of the instrument.

Prism or Grating Mounting. The dispersing element, whether prism or grating, is mounted immediately in front of the collimator, and in approximately the position shown in the diagram. In the case of the grating, rotation should be permitted through at least 90 degrees. The axis of rotation should intersect the optical axis of the collimator, and be perpendicular thereto. The grating itself should have its center on the optical axis, and have its lines in a vertical plane.



Optical system of the spectroscope. A is the angle of incidence to make D the angle of minimum deviation. The position of a grating in place of a prism is shown by the dashed lines. Detail of the slit is not shown.

View Telescope. Use the lens of longer focal length for the view telescope. The view telescope is merely an ordinary refracting telescope, with the eyepiece at principal focus, and the objective is placed close to the prism or grating. It is preferable if the view telescope is mounted so as to swing about the axis of rotation of the prism or grating, but this feature is not essential. If the view telescope rotates, the prism or grating need not do so. In this case, the grating is mounted perpendicularly to the optical axis of the collimator, and the prism is mounted at the angle of minimum deviation, which is, for a 60-degree prism, index N, sin A=N/2, where A is the angle between the normal of the prism face and the entering ray. The view telescope, of course, must be blackened inside.

Mounting. No general type of mounting can be given. It will be up to the individual to mount the instrument so that it is readily attachable to his telescope, with the slit in the center of the telescope's focal plane. The instrument will weigh several pounds, and so must be counterbalanced.

Using the Instrument. In use, the image of a star, or the sun, is focused on the slit, and the spectrum is observed through the eyepiece of the view telescope. If a grating is used, the entire spectrum will not be visible in the field of view, and the view telescope or grating must be rotated slightly to bring the remainder into the field.

SKY-GAZERS EXCHANGE

Classified advertisements accepted for this column at 30c a line per insertion, 7 words to the line. Minimum ad 3 lines. Remittance must accompany orders. Address Ad Dept., Sky and Telescope, Harvard College Observatory, Cambridge, Mass.

FOR SALE: 6" f/7 parabolic reflector; good polish and figure; unaluminized. Reasonably priced at $20. Write J. F. Gregory, 3825 Bainbridge Road, Cleveland Heights, Ohio.

EVERYTHING for the AMATEUR
Telescope Maker
Quality Supplies, Precision Workmanship with a Money Back Guarantee.
KITS—OUR SPECIALTY
COMPLETE 6" KIT $3.75
PYREX KIT, 6" 5.50
Other Sizes, Proportionately Low
PYREX MIRRORS
Made to order, correctly figured, polished, parabolized and aluminized.
ALUMINIZING
We guarantee a Superior Reflecting Surface, Optically Correct Finish. Will not peel or blister. Low prices.
MIRRORS TESTED FREE
PRISMS—EYEPIECES—ACCESSORIES
FREE: Catalog—Telescopes, Microscopes, Binoculars, etc.
Instruction for Telescope Making . . . 10c
PRECISION OPTICAL SUPPLY CO.
1001 East 163rd St. New York, N. Y.

Astronomical and Astrophysical Instruments
ROSS LENSES
SPECIAL LENSES, MIRRORS and PRISMS, of all sizes
The Copernican Planetarium in the HAYDEN PLANETARIUM was designed and constructed by
J. W. FECKER
2016 Perrysville Avenue
PITTSBURGH - PA.

BOOKS AND THE SKY

MATTER, ENERGY, AND RADIATION

J. R. DUNNING AND H. C. PAXTON. McGraw-Hill Book Company, New York, 1941. 668 pages. $3.50.

THE book under review is an example of a type which had been growing increasingly popular in the few years immediately preceding the outbreak of the war. It presents the textual material for the first part of a two-year sequence in the sciences adapted to the needs of students "who do not intend to enter the sciences professionally." This material begins with a brief presentation of astronomy and is then completed by a systematic account of physics.

In line with the usual procedure in books of this character, great emphasis is laid on the significance of science and upon the nature of scientific thought. Astronomy is included not so much for its own sake as for illustrative material on these points.

It seems to this reviewer that a discussion of the meaning of science and the nature of scientific method can hardly be carried on with profit at the level of a book of this character. Such a discussion requires considerable knowledge and maturity. It is quite as difficult as the mastery of any of the sciences.

But it must not be assumed from what has just been remarked that the book is without value. It has, in fact, considerable value. Those coming to the study of physics for the first time will find an agreeably written introduction to all of its branches, classical and ultra-modern. By giving simple, if not precise or profound, explanations of a host of technical terms and ideas, this book will provide such a reader with a confidence born of verbal familiarity, enabling him in turn to follow current progress and to find his own way in more advanced works.

The account of astronomy is unfortunately marred by a number of slips which betray the fact that the two authors are physicists, not astronomers.

We read once again of Newton withholding his ideas until Picard's measurement of the earth was announced; we read that there is no "rigorous" solution of the three-body problem; that Herschel named his new planet Uranus; that island universes are galactic nebulae. The distinction between binaries and double stars is lost; Delta Cephei loses its position of honor as the prototype of the Cepheid variables; and finally, in the part on physics, is the old fairy tale about two pieces of ice being rubbed together in a vacuum.

In concluding their account of astronomy, the authors make some very good comments about science in general. Particularly fortunate is their statement that even an imperfect theory is of value. The part played in the history of science by theories that were imperfect or incomplete or even downright false is often overlooked.

There are many splendid diagrams and pictures in the volume. Together with their explanatory captions they greatly enhance its value.

ROBERT I. WOLFF
College of the City of New York

A COMET STRIKES THE EARTH

H. H. NININGER. American Meteorite Laboratory, Denver, Colo., 1942. Unpaged. 35 cents; 3 for $1.00.

DR. H. H. Nininger, director of the Meteorite Laboratory of the Colorado Museum of Natural History, describes the tests to distinguish the various types of meteorites, the conditions of their fall, and gives a possible hypothesis of their origin. The Arizona and Odessa craters are discussed in detail. Among the photographs is one of the magnetic rake which he has used to locate buried fragments, and which has helped him to discover more than one half of all the known meteorites in the world. A unique feature is the inclusion of a certified specimen of a meteorite. This is a readable and worthwhile booklet.

PERCY W. WITHERELL
Bond Astronomical Club

WEATHER ELEMENTS

THOMAS A. BLAIR. Prentice-Hall, Inc., New York, Revised Edition, 1942. 401 pages. $5.00 trade; $4.00 school.

THE old saying that everybody talks about the weather but nobody does anything about it no longer holds. Not everyone can talk freely about even the weather these days, for the war has made meteorological topics taboo. As weather maps and advance information disappear from the newspapers, the layman finds himself, for the duration, becoming more and more his own weatherman.

For a decade and a half, Blair's *Weather Elements* has been a well-known standard text on elementary meteorology. The revised edition contains many new features, including a discussion of isentropic analysis, a set of six new consecutive weather maps, and present day air-mass classification symbols. The book is copiously illustrated with pictures, charts, and diagrams.

The final chapter in the new edition, "The United States Weather Bureau," gives one of the best historical accounts of the development of meteorology in this country that is to be found anywhere. It is a welcome supplement, therefore, to the final chapter in another widely used textbook, Petterssen's *Introduction to Meteorology*, which deals almost exclusively with the European side of the history of this science.

Weather Elements contains useful Fahrenheit-Centigrade equivalents, barometric tables, and precipitation statistics. The bibliography is especially complete. This very readable book should find readers ranging all the way from amateur weather prophets to students of the role of climatology in global warfare.

RALPH S. BATES
Massachusetts Institute of Technology

NEW BOOKS RECEIVED

A COMET STRIKES THE EARTH, *H. H. Nininger*, 1942. *American Meteorite Laboratory, Denver.* Unpaged. 35c; 3 for $1.00.
An attractive pamphlet, with a specimen of Meteor Crater iron an inherent part of the book, discusses in layman's language meteors and meteorites, and how to recognize the latter.

PHYSICAL SCIENCE, *Ehret, Spock, Schneider, van der Merwe, and Wahlert.* 1942, *Macmillan.* 639 pp. $3.90.
A textbook in the modern manner covers the various fields of the physical sciences—astronomy, chemistry, geology, mathematics, and physics. Exercises and references appear at the end of each chapter.

MANUAL OF ASTRONOMY
BY
R. W. Shaw and S. L. Boothroyd
Cornell University
44 observational and laboratory exercises for elementary students and amateurs. Star Charts, Moon Maps, Ecliptic Charts, Data Forms, and Special Graph Papers Included
$3.00
CORNELL CO-OP
Ithaca, N. Y.

Splendors of the Sky
Compiled by
Charles and Helen Federer
36 pages of astronomical photographs and pictures, many full-size — 9x12. Fine-screen halftones printed on heavy coated paper. Captions in simple terms.
As an addition to your own library, or for a gift to friends or children, **Splendors of the Sky** cannot be equalled at this price. Also, fine for teachers with projects in astronomy; to cut up for scrapbooks; for science survey courses; to give away at your observatory; just to enjoy looking at.
25c postpaid, $2.75 a dozen.
THE BOOK CORNER
Hayden Planetarium
New York City

STAR MAPS FOR BEGINNERS
by
I. M. LEVITT and
ROY K. MARSHALL
A new projection minimizes distortion, and shows the proper sky for a given time. Twelve maps, each seven inches square, show white stars on a black sky. A 7,500-word history of the constellations, and tables of planet positions add to the usefulness of
STAR MAPS FOR BEGINNERS
50 cents, postpaid
Special rates to groups
Order from the authors at
THE FRANKLIN INSTITUTE
Philadelphia, Pa.

OBSERVER'S PAGE

All times mentioned on the Observer's Page are Eastern war time.

THE EQUINOX AND THE SOUTHERN CROSS

THE sun arrives at 12 hours right ascension on September 23rd at 12:17 p.m. and autumn begins in our Northern Hemisphere. The sun's position at this moment, usually known as the autumnal equinox, is where the sun crosses the equator on its journey to southern latitudes. The opposite point on the celestial globe, the vernal equinox, is on the meridian at midnight on that date, and if skies are favorable, it is worth the effort to stay up until that hour to see the arrangement of the zodiacal constellations. Their positions will be the same as on December 21st at 6 p.m., as described in my article in the July, 1941, issue of The SKY. This always affords an excellent opportunity to become familiar with half of the ecliptic, extending from its southern point on the western horizon to its northerly point on the eastern horizon. It is only the observer in equatorial latitudes who can see the equinox overhead at this time.

Back in the 1920's, I was on a steamer sailing from Rangoon, Burma, to Batavia, Java. Our course was slightly east of due south, because of a scheduled stop at Emmahaven on the island of Sumatra. I had been invited to give a talk on the stars to the passengers, and arranged to have them gather on the sun deck where we would have an uninterrupted view of the sky. The date was March 6th, two weeks before the vernal equinox, with conditions opposite to those in September. We could expect to see the autumnal equinox overhead shortly after midnight.

We crossed the equator at sundown, so when I started my talk at 10 p.m., we were only one degree south of that imaginary line. The good-natured captain steered a course due south for four hours, until the passengers decided to turn in shortly before 2 a.m. The tops of the ship's masts marked our celestial meridian. That night stands out as one of the most interesting and colorful in my experience with stargazing. The sky was without a blemish, and the 400 passengers in tropical evening dress seated on the deck or lounging in steamer chairs made a picturesque setting. I gave an illustrated talk with nature doing the illustrating, and an intelligent audience helped pass the time with many worthwhile questions.

During the four hours, we watched the constellations shift gradually toward the west, until at about 12:30 a.m. the equinox was at the zenith, with Leo, Cancer, and Gemini extending to the northwest and Virgo, Libra, and Scorpius to the southeast. It was a simple matter to explain the path of the ecliptic, since it was so well marked in those constellations by such bright stars as Beta Scorpii, Alpha Librae, Spica, Regulus, Delta Geminorum, and the Praesepe cluster.

Just prior to 1 a.m., the Southern Cross and Corvus were on the meridian, the latter so high we had to crane our necks to see it, but the Cross, 30 degrees above the southern horizon, appeared as a guiding beacon below the top of our forward mast. These two groups of stars are similar in formation, both kite-shaped, with Corvus the larger, measuring about eight degrees from top to bottom and the Cross about six, but the latter containing much brighter stars.

The numerous faint stars and nebulous portions of the Milky Way near the Southern Cross detract from its beauty, and it is disappointing to those seeing it for the first time. To get the perfect picture, it should be seen on a bright moonlit night when the faint neighbors are blotted out. There will then remain the four stars of the Cross, and above them Gamma and Delta of Centaurus, which form with the top star of the Cross, Gamma, an inverted isosceles triangle. It doesn't require much imagination to picture these three stars as a triangular chain suspending the Cross in the sky. This is best seen an hour before culmination, when the Centaurus stars form a horizontal line. In addition to the six stars mentioned, those two exceptionally brilliant stars, Alpha and Beta Centauri, are in line on the left of the picture, pointing to the Cross. All of this may be seen from the most southerly latitudes of the United States. I have seen the Cross, standing on the horizon, in latitude 27° north, a little north of Miami, Fla. But this was at sea.

EQUATION OF TIME

September 1st is one of the four days of the year when the sun is on the meridian at noon—the equation of time equals zero. Those wishing to establish their local meridian will find on that date that shadows cast by the sun extend exactly north and south at 1:00 p.m. (local war time).

On the top floor of the National Museum in Naples, Italy, there is a very large room, empty except for paintings hanging on the walls. Diagonally across the room there lies a brass plate set flush with the floor. From memory, I recall the plate to be about one foot wide and 20 feet long, with a groove in the center running the entire length. This groove represents the local meridian, and on each side of it are the 12 signs of the zodiac carved in brass. A small hole in the wall of the south corner of the room permits a ray of sunlight to strike the plate at noon and to rest momentarily in the groove alongside of the zodiac sign in which the sun happens to be at the time. Due to the difference between apparent and mean solar time, the spot of sunlight will be in the groove at 12:00 m. on only four days of the year, April 16th, June 14th, September 1st, and Christmas. On other days in the year it will be late or early, varying from $14^m\ 20^s$ late on February 12th, to $16^m\ 23^s$ early on November 3rd. These dates vary slightly from year to year.

THE HARVEST MOON

The full moon on September 24th will be at the vernal equinox, and so will be a true harvest moon as described in my article in the September, 1941, issue of The SKY. On September 25th, moonrise will be only 32 minutes later than on the 24th in latitude 40° N. This interval gradually decreases in more northern latitudes until it is only 17 minutes at 60° N.

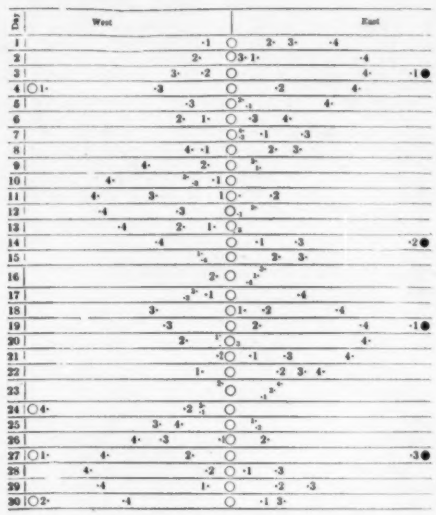
By Jesse A. Fitzpatrick

JUPITER'S SATELLITES

On September 7th, after 4:56 a.m., the four moons will be east of the primary. On September 10th, the four moons will be west of the primary and in numerical order, *I* being nearest to Jupiter.

The transit ingress of *IV*, at 4:09 a.m. on September 24th, will be the first time that we have witnessed this since January 4, 1939. In the interim, the satellite has passed either north or south of the primary, depending on whether it was in inferior or superior conjunction.

Jupiter's four bright moons have the positions shown below at 4:00 a.m., E.W.T. The motion of each satellite is from the dot to the number designating it. Transits of satellites over Jupiter's disk are shown by open circles at the left, and eclipses and occultations by black disks at the right. From the **American Ephemeris.**



PHASES OF THE MOON

Last quarter .....September 2, 11:42 a.m.
New moon .....September 10, 11:53 a.m.
First quarter ....September 17, 12:56 p.m.
Full moon .....September 24, 10:34 a.m.

ANSWERS TO DO YOU KNOW?

(Questions on page 17)

I. 1, a; 2, d; 3, d; 4, d; 5, b; 6, a; 7, a; 8, a; 9, a; 10, c.

II. a. 50.2 is the precession of the equinoxes in seconds of arc per year.
b. 20 is the number of 1st-magnitude stars.
c. .01673 is the eccentricity of the earth's orbit.
d. 3.259 is the number of light-years per parsec.
e. 0″.761 is the parallax of Proxima Centauri.
f. 3969 is the H line of calcium in angstrom units.

III. 1. The rocket principle.
2. Each rocket should be in line with the center of gravity, otherwise it would produce violent rotation.
3. Absorption of radiant energy. If one side is mirrored, the other finished in an absorbing material, there will be a slight pressure toward the second side. Even if the effect were multiplied a few million times, it would still be negligible.

OCCULTATIONS—SEPTEMBER, 1942

Local station, lat. 40° 48′.6, long. 4^h 55.8^m west.

Date	*Mag.*	*Name*	*Immersion*	*P.**	*Emersion*	*P.**
Sept. 1	4.3	f Tauri	0:56.4 a.m.	92°	1:59.3 a.m.	228°
2	3.9	γ Tauri	1:10.1 a.m.	27°	1:56.0 a.m.	299°
2	6.4	70 Tauri	4:27.8 a.m.	59°	5:54.4 a.m.	266°
16	6.5	90 B Ophiuchi	9:38.8 p.m.	71°	10:41.2 p.m.	294°
18	6.1	171 B Sagittarii	11:12.3 p.m.	62°	0:15.9 a.m. (19)	280°
18	6.3	173 B Sagittarii	11:29.9 p.m.	24°	0:08.3 a.m. (19)	318°
20	6.0	94 B Capricorni	8:23.4 p.m.	87°	9:42.1 p.m.	244°
27	5.9	BD + 11° 445	11:53.8 p.m.	85°	1:04.3 a.m. (28)	230°
29	6.0	179 B Tauri	4:56.9 a.m.	103°	6:16.8 a.m.	229°
30	5.7	318 B Tauri	4:32.6 a.m.	78°	6:05.7 a.m.	259°

* P is the position angle of the point of contact on the moon's disk measured eastward from the north point.

There will be a daylight occultation of Aldebaran (α Tauri) on September 2nd. The predicted time for the *emersion*, which might be observed if conditions are perfect, is 12:20.6 p m. at our local station; position angle, 320°.

THE PLANETS IN SEPTEMBER

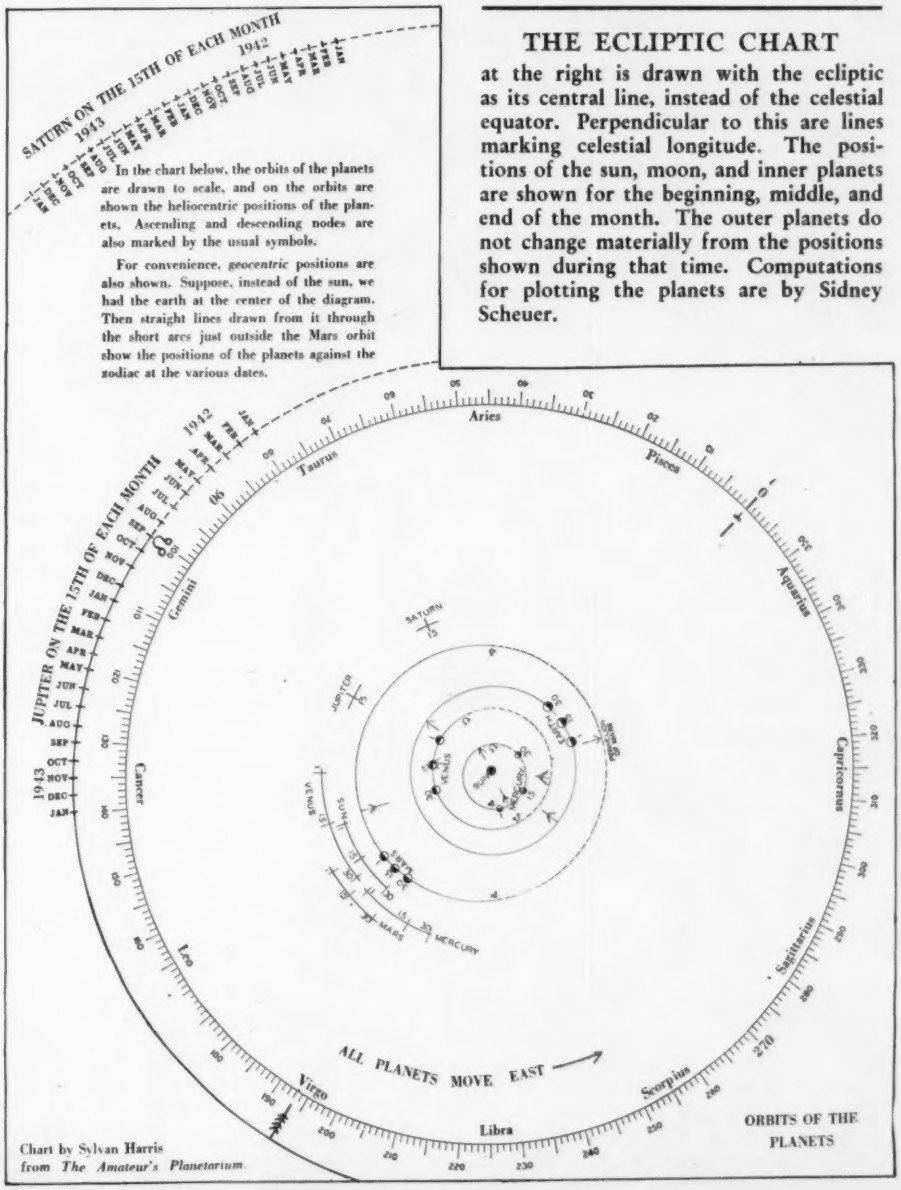
Mercury will be at greatest eastern elongation, 26° 40′, on September 15th. Its declination, 12°.5 south of the sun, and the low ecliptic-horizon angle will cause the planet to be too near the horizon for good observation in mid-northern latitudes. Southern-Hemisphere observers will have a chance to see the planet in a dark sky.

Venus, *Mars*, and *Neptune* are too close to the sun to be of interest.

Jupiter, in Gemini, will be 10 minutes north of the star δ, on September 1st. The latter is a double star that has not appeared as yet in our lists. Its magnitude is 3.5, and its companion's, 8.5. Separation is 7″.0, and position angle, 212°.

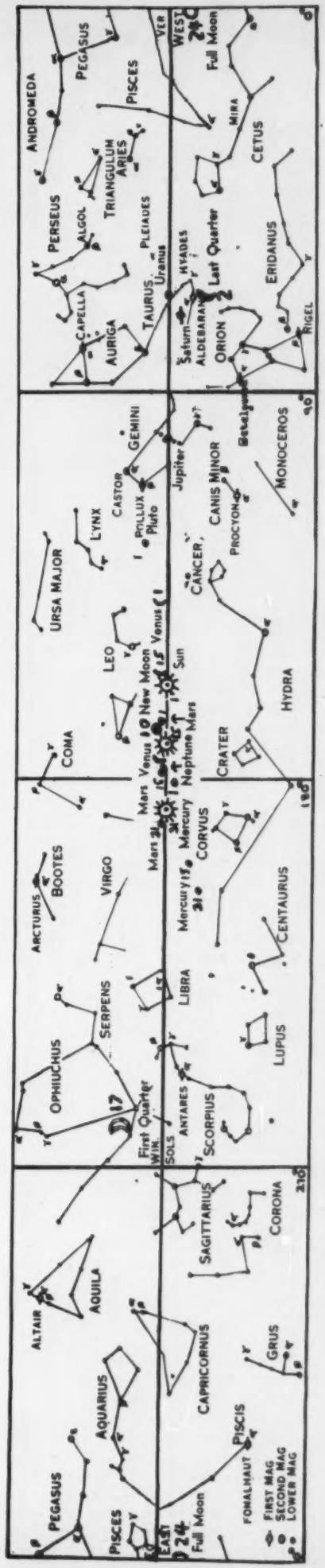
Saturn, in Taurus, will begin its retrograde motion on September 25th.

Uranus, in Taurus, midway between the Pleiades and Hyades, will begin its retrograde motion on September 10th.


SATURN ON THE 15TH OF EACH MONTH
1942
1943
In the chart below, the orbits of the planets are drawn to scale, and on the orbits are shown the heliocentric positions of the planets. Ascending and descending nodes are also marked by the usual symbols.
For convenience, *geocentric* positions are also shown. Suppose, instead of the sun, we had the earth at the center of the diagram. Then straight lines drawn from it through the short arcs just outside the Mars orbit show the positions of the planets against the zodiac at the various dates.
JUPITER ON THE 15TH OF EACH MONTH
Aries
Taurus
Gemini
Cancer
Leo
Virgo
Libra
Scorpius
Sagittarius
Capricornus
Aquarius
Pisces
ALL PLANETS MOVE EAST
ORBITS OF THE PLANETS
Chart by Sylvan Harris
from *The Amateur's Planetarium*.

THE ECLIPTIC CHART

at the right is drawn with the ecliptic as its central line, instead of the celestial equator. Perpendicular to this are lines marking celestial longitude. The positions of the sun, moon, and inner planets are shown for the beginning, middle, and end of the month. The outer planets do not change materially from the positions shown during that time. Computations for plotting the planets are by Sidney Scheuer.



THE APPARENT POSITIONS IN THE HEAVENS OF THE SUN, MOON, AND PLANETS.

THE STARRY HEAVENS IN SEPTEMBER

By Leland S. Copeland

AUTUMN'S advent is heralded in the eastern and southeastern sky of mid-September at 10 p.m., war time, by three dark constellations of the zodiac — Aries, Pisces, and Aquarius. They seem to have dimmed their lights to match the fading beauty of the earth. But a bright harbinger of winter is rising in the northeast, the clustered Pleiades.

Though the constellations last for ages, so that they gleam above us almost as they shone on the ancient world, they must be listed among useful fictions. They are merely the stars from our point of view, which we share with inhabitants of Mars and Venus, if any. And in late summer our outlook toward the southeast is unusually gloomy.

Yet many amateurs repeatedly will observe the Water Jar of Aquarius, four stars, including at its center the handsome double, ζ. Through this jar passes the celestial equator. Noteworthy also is the dimly sparkling water, which curves down to Fomalhaut in Piscis Austrinus.

The splendor of summer lingers in the western half of the stellar dome, and the Milky Way, with Cygnus on the meridian, still is magnificent as it stretches from Scorpius, dying in the southwest, to the Ethiopian family ruling the north.

In the September sky nestle several exceptionally good open clusters. Owners of amateur telescopes should look at the following: N.G.C. 6940, Vulpecula, $20^h\ 30^m$, $+27°\ 58'$; M71, Sagitta, $19^h\ 49^m$, $+\ 18°\ 31'$; M11, Scutum, $18^h\ 45.7^m$, $-6°\ 23'$; M16, Serpens, $18^h\ 13^m$, $-13°\ 49'$; M23, Sagittarius, $17^h\ 51^m$, $-19°$.

Capricornus shares the meridian with the Northern Cross and the wee, but unforgettable, Dolphin. In the northwest, Ursa Major is sliding into its autumnal position, close to the ground—signal to earthly bears to prepare for hibernation, according to a droll myth. Following the Big Dipper are Canes Venatici, Boötes with orange-hued Arcturus, and the Northern Crown. In the southwest, Ophiuchus firmly holds the great snake, and above him shines the strange, ancient figure of Hercules.

MYSTERIOUS ENGONASIN

A PHANTOM, toiling on his knees and busy with a task that no living man can explain— that is the description that Aratos, best-known amateur astronomer of the ancient world, gives of the constellation we now call Hercules. Aratos, who wrote in about 275 B.C., says that the mysterious figure was named Engonasin, a melodious Greek term for On-His-Knees.

From our viewpoint On-His-Knees might better be called On-His-Head, because Hercules now is upside down. He seems to be leaning low to whisper into the ears of Ophiuchus. But when the Pyramids were built, the head of Hercules passed through or north of the zenith.

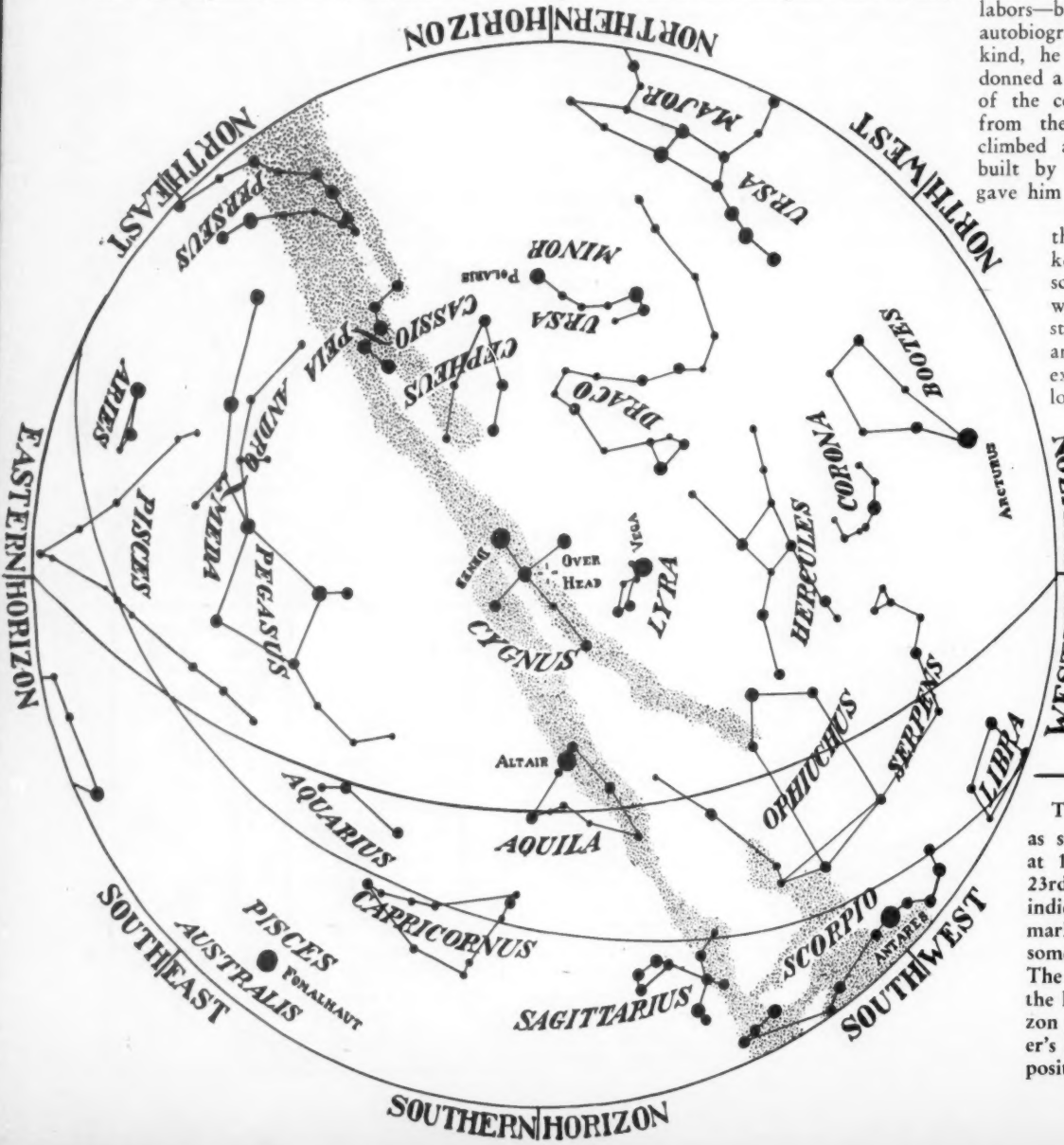
If, borrowing H. G. Wells' time machine, we could dart back to ancient Sumeria and pass an evening with a priest-astronomer on some tower-temple, perhaps we should recover the lost story of the mysterious kneeler, of which only faded memories remain.

The constellation was renamed in honor of Hercules, son of Zeus and great-grandson of Perseus and Andromeda. His father was also his great-great-grandfather, and his noblest descendant was Leonidas, Spartan king, who died with the 300 at Thermopylae.

No doubt exists about the tasks that Hercules undertook. He slew Leo, the Nemean lion; killed Hydra, the nine-headed water snake of Argos; cleansed the Augean stables; garnered the golden apples guarded by Draco; brought Cerberus from the underworld; and accomplished seven other great labors—but was too modest to write an autobiography. Like other saviors of mankind, he suffered an untimely death. He donned a robe poisoned through the trickery of the centaur, Nessus. Unable to escape from the clinging garment, the demigod climbed a mountain and died on a pyre built by his own stout hands. But Zeus gave him an abode in the starry heavens.

Hercules ranks fifth largest among the constellations. It resembles a keystone resting on an inverted coal scuttle; or a butterfly, say persons with a weak sense of humor. The starry left arm reaches toward Lyra, and the right or club-holding arm extends to the head of Serpens. Below the left hand is a small group of stars, which represent Cerberus, the three-headed dog.

Among the wonders of Hercules are several noteworthy doubles, including α, δ, and ϱ, and two globular clusters. M13, only naked-eye globular north of the celestial equator, is on the western edge of the Keystone, and M92 lies between the northeast corner of the Keystone and the head of Draco.



THE STARS FOR SEPTEMBER

as seen from mid-northern latitudes. at 10 p.m., Sept. 7th; 9 p.m., Sept. 23rd. Magnitudes of the stars are indicated by the sizes of the disks marking the stars, and the names of some of the brighter stars appear. The ecliptic and equator are shown, the latter touching the east-west horizon points. See chart on the "Observer's Page" for sun, moon, and planet positions.

HERE AND THERE WITH AMATEURS

This is not intended as a complete list of societies, but rather to serve as a guide for persons near these centers, and to provide information for traveling amateurs who may wish to visit other groups.

City	*Organization*	*Date*	*P.M.*	*Season*	*Meeting Place*	*Communicate with*
BOSTON	Bond Ast. Club	1st Thu.	8:15	Oct.-June	Harvard Obs.	Homer D. Ricker, Harvard Observatory
"	A.T.M.s of Boston	2nd Thu.	8:15	Sept.-June	Harvard Obs.	F. I. Noyes, 340 Warren St., Brockton, Mass.
BROOKLYN, N.Y.	Astr. Dept., B'klyn Inst.	Rd. Table 3rd Thu.	8:00	Oct.-April	Brooklyn Inst.	William Henry, 154 Nassau St., N.Y.C., *BA*. 7-9473
BUFFALO	A.T.M.s & Observers	1st, 3rd Fri.	8:00	Oct.-June	Mus. of Science	J. J. Davis, Museum of Science
CHATTANOOGA	Barnard A. S.	4th Fri.	7:30	All year	Chattanooga Obs.	C. T. Jones, 1220 James Bldg., *CHat*. 6-8341
CHICAGO	Burnham A. S.	2nd, 4th Tue.	8:00	Sept.-June	Congress Hotel	Wm. Callum, 1435 Winona Ave.
CINCINNATI	Cin. A.A.	2nd Fri.	8:00	Sept.-June	Cincinnati Obs.	Dan McCarthy, 1622 DeSales Lane
CLEVELAND	Cleveland A. S.	Fri.	8:00	Sept.-June	Warner & Swasey Obs.	Mrs. Royce Parkin, The Cleveland Club
DAYTONA BEACH	D. B. Stargazers	Alt. Mon.	8:00	Nov.-June	500 S. Ridgewood Ave.	Rolland E. Stevens, 500 S. Ridgewood
DETROIT	Detroit A. S.	2nd Sun.	3:00	Sept.-June	Wayne U., Rm. 187	E. R. Phelps, Wayne University
"	Northwest A.A.S.	1st, 3rd Tue.	8:00	Sept.-June	Redford High Sch.	A. J. Walrath, 14024 Archdale Ave.
DULUTH, MINN.	Duluth Ast. Club	1st, 3rd Sat.	8:00	All year	Darling Obs.	W. S. Telford, 126 N. 33rd Ave. E.
FT. WORTH	Tex. Observers	No regular meetings				Oscar E. Monnig, 1010 Morningside Dr.
GADSDEN, ALA.	Ala. A.A.	1st Thu.	7:30	All year	Ala. Power Audit.	Brent L. Harrell, 1176 *W* or 55
INDIANAPOLIS	Indiana A.A.	1st Sun.	2:00	All year	Central Library Audit.	E. W. Johnson, 808 Peoples Bank Bldg.
JOLIET, ILL.	Joliet A.S.	Alt. Tue.	8:00	Oct.-May	Jol. Mus. & Art Gall'y	Monica L. Price, 403 Second Ave.
LOS ANGELES	L.A.A.S.	2nd Thu.	8:15	.....	2606 W. 8th St.	Charles Ross, 2606 W. 8th St.
LOUISVILLE, KY.	L'ville A.S.	3rd Tue.	8:00	Sept.-May	Women's Bldg., Univ. of Louisville	Mary Eberhard, 3-102 Crescent Ct., *Taylor* 4157
MADISON, WIS.	Mad. A.S.	2nd Wed.	8:00	All year	Washburn Obs.	C. M. Huffer, Univ. of Wisconsin
MILWAUKEE	Milw. A.S.	1st Thu.	8:00	Oct.-May	Marquette U., Eng. Col.	E. A. Halbach, *Hopkins* 4748
MOLINE, ILL.	Pop. Ast. Club	2nd Tue.	7:30	All year	Sky Ridge Obs.	Carl H. Gamble, Route 1
NEW HAVEN	New Haven A.A.S.	1st Sat.	8:00	Sept.-June	Yale Obs.	F. R. Burnham, 820 Townsend Ave., 4-2618
NEW YORK	A.A.A.	1st, 3rd Wed.	8:15	Oct.-May	Amer. Mus. Nat. Hist.	G. V. Plachy, Hayden Plan., *EN*. 2-8500
" "	Junior Ast. Club	Alt. Sat.	8:00	Oct.-May	Amer. Mus. Nat. Hist.	J. B. Rothschild, Hayden Plan., *EN*. 2-8500
NORWALK, CONN.	Norwalk Ast. Soc.	Last Fri.	8:00	Sept.-June	Private houses	Mrs. A. Hamilton, 4 Union Pk., 6-4297
OAKLAND, CAL.	Eastbay A.A.	1st Sat.	8:00	Sept.-June	Chabot Obs.	Miss H. E. Neall, 6557 Whitney St.
PHILADELPHIA	A.A. of F.I.	3rd Fri.	8:00	All year	The Franklin Inst.	Edwin F. Bailey, *R.t*. 3050
"	Rittenhouse A.S.	2nd Fri.	8:00	Oct.-May	The Franklin Inst.	A. C. Schock, *Rit*. 3050
PITTSBURGH	A.A.A. of P'burgh	2nd Fri.	8:00	Sept.-June	Buhl Planetarium	Louis E. Bier, 402 Cedarhurst
PONTIAC, MICH.	Pontiac A.A.A.	2nd Mon.	8:00	All year	Cranbrook Inst. of Sci.	J. P. Coder, 2675 Voorheis Rd., 2-9419
PORTLAND, ME.	A.S. of Maine	2nd Fri.	8:00	All year	Private homes	H. M. Harris, 27 Victory Ave., S. Portland
PORTLAND, ORE.	Ast. Study Group	1st Mon.	8:00	All year	420-3 Av., Rm. 212	H. J. Carruthers, 427 S. 61 Ave.
PROVIDENCE, R.I.	Skyscrapers	1st Wed.	8:00	All year	Wilson Hall, Brown U.	Ladd Obs., Brown U., *GA*. 1633
READING, PA.	Reading-Berks A.C.	2nd Thu.	8:00	Sept.-June	Albright College	Mrs. F. P. Babb, 2708 Filbert Ave.
RENO, NEV.	A.S. of Nev.	4th Wed.	....	All year	Univ. of Nevada	G. B. Blair, University of Nevada
ROCHESTER, N.Y.	Roch. Ast. Club	Alt. Fri.	8:00	Oct.-May	Eastman Bldg., Univ. of Rochester	M. L. Groff, 400 University Ave.
SAN ANTONIO	San Ant. A.A.	3rd Mon.	8:00	All year	Le Villela	R. B. Poage, 807 Hammond Ave.
SCHENECTADY	S'tady Ast. Club	3rd Mon.	8:00	All year	Observatory site	C. H. Chapman, 216 Glen Ave., Scotia
SOUTH BEND, IND.	St. Joseph Val. Ast.	Last Tue.	8:00	All year	928 Oak St.	Fannie Mae Chupp, 224 Seebirt Pl.
STAMFORD, CONN.	Stamford Ast. Soc.	4th Wed.	8:00	Oct.-June	Stamford Museum	Stamford Mus., 300 Main St.
TACOMA, WASH.	Tacoma A.A.	1st Mon.	....	All year	Coll. of Puget Sound	Geo. Croston, *Gar*. 4124
WASHINGTON, D.C.	Nat'l. Cap. A.A.A.	1st Sat.	8:00	Oct.-June	U. S. Nat'l. Museum	Stephen Nagy, 104 C St., N.E., *Linc*. 9487-J
WICHITA, KANS.	Wichita A.S.	2nd Tue.	8:00	All year	E. High Sch., Rm. 214	S. S. Whitehead, 2322 E. Douglas, 33148
YAKIMA, WASH.	Yak. Am. Astr'mers	2nd Tue.	7:30	All year	Y.M.C.A. Audit.	J. L. Thompson, 4 S. 10 Ave., 21455

Sky and Telescope is official publication of many of these societies.

* *

PLANETARIUM NOTES

Sky and Telescope is official bulletin of the Hayden Planetarium in New York City and of the Buhl Planetarium in Pittsburgh, Pa.

★ **THE BUHL PLANETARIUM** presents *in September*, FLYING AROUND THE WORLD.

Even in time of war, travel in the Planetarium to faraway places is as easy as ever. Sitting in air-conditioned comfort, we circumnavigate the globe in one short hour's time. This war makes us conscious that we do live, after all, on a global world—on a slightly flattened sphere—just as our school books always said we do.

In "Flying Around the World," we are able to form a comprehensive picture of how conditions change as we move about on this round earth from one spot to another. We see what different vistas of the universe are presented to Australians and South Americans, Chinese and Russians. We discover places where December means summer, where there are no seasons at all, where the sun rises and sets but once a year, where there is no noon or midnight. Many visitors will see for the first time the aurora australis, southern counterpart of our northern lights; meteors at the south pole; a solar eclipse in the Arctic. Here is a chance, even in wartime, to get the globe-trotter's point of view.

★ **THE HAYDEN PLANETARIUM** presents *in September*, AUTUMN SKIES. *(See page 12.)*

In October, SAILING THE SEVEN SEAS.

Here the Hayden Planetarium will present a colorful pageant of the development of navigation. From ancient days to the present, man has constantly sought new methods for finding his way over the earth. The early Polynesians, the Columbus age of explorers, the windjammer, the modern flying fortress—each had its own techniques. By means of complicated projection, music, and newly-created effects, the story will be unfolded on the Planetarium sky. Nor will the principles of navigation be neglected in this popular story.

★ SCHEDULE BUHL PLANETARIUM

Tuesdays through Fridays........................3 and 8:30 p.m.
Saturdays ....2, 3, and 8:30 p.m.
Sundays and Holidays........................3, 4, and 8:30 p.m.
(Building closed Mondays)

★ STAFF—*Director*, Arthur L. Draper; *Lecturer*, Nicholas E. Wagman; *Business Manager*, Frank S. McGary; *Public Relations*, John J. Grove; *Curator of Exhibits*, Fitz-Hugh Marshall, Jr.

★ SCHEDULE HAYDEN PLANETARIUM

Mondays through Fridays..................2, 3:30, and 8:30 p.m
Saturdays ....11 a.m., 2, 3, 4, 5, and 8:30 p.m
Sundays—Mutual Network Broadcast—Coast-to-Coast..9:30–10 a.m.
Sundays and Holidays...................2, 3, 4, 5, and 8:30 p.m.

★ STAFF—*Honorary Curator*, Clyde Fisher; *Curator*, William H. Barton, Jr.; *Assistant Curators*, Marian Lockwood, Robert R. Coles (on leave in Army Air Corps), John Ball, Jr.; *Staff Assistant*, Fred Raiser; *Lecturers*, Asa Tenney, Charles H. Coles.